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ENVIRONMENTAL ASSESSMENT RELATED TO THE CONVERSIONS OF BOILERS NO. 1 AND NO. 5 AT ARGONNE NATIONAL LABORATORY

ARGONNE NATIONAL LABORATORY, ARGONNE, ILLINOIS

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ENVIRONMENTAL ASSESSMENT

RELATED TO

THE CONVERSIONS OF BOILERS NO. 1 AND NO. 5

AT

ARGONNE NATIONAL LABORATORY

by the

Division of Environmental Impact Studies

ARGONNE NATIONAL LABORATORY
9700 South Cass Avenue
Argonne, Illinois 60439

for the

U.S. Department of Energy

December 1980

ABSTRACT

This environmental assessment addresses the conversion of ANL's Boiler No. 5 to high-sulfur-coal firing and the replacement of the old Boiler No. 1 with an atmospheric fluidized-bed combustion unit to burn coal. Attention is especially focused on the air-quality impacts expected during the period between the initial coal conversion and the installation of pollution-control equipment on Boiler No. 5. Burning 50,000 t (55,000 tons) of coal each year will replace the consumption of 3.5×10^7 m^3 (1.22×10^9 ft^3) of natural gas and 2900 m^3 (760,000 gal) of fuel oil.

SUMMARY

1. As part of ANL's energy-conservation program and in compliance with a proposed ERA prohibition order to stop burning oil and gas, the Laboratory is converting Boiler No. 5 to high-sulfur-coal firing and is replacing the old Boiler No. 1 with an atmospheric fluidized-bed combustion unit to burn coal. The same coal and coal-handling equipment will be used for both boilers.

2. With the planned conversion and replacement, burning 50,000 t (55,000 tons) of high-sulfur coal each year will replace the consumption of about 3.5×10^7 m^3 (1.22×10^9 ft^3) of natural gas and 2900 m^3 (760,000 gal) of fuel oil.

3. Boiler No. 5 will be prepared and rehabilitated for coal firing, the coal handling/storage system repaired and upgraded, and particulate- and sulfur-removal systems procured and installed to meet applicable emission standards. Boiler No. 1 will be replaced by a new atmospheric fluidized-bed boiler with cyclones and a baghouse for particulate removal.

4. New construction will take place largely within or immediately adjacent to the present boiler-plant area, and about 1.3 ha (3.2 acres) near the boiler building will be required for coal storage. The area is now partly in use for coal storage and protected by dikes, and no increased flooding problems are expected.

5. Boiler ash will be collected by the Du Page County Highway Department for use in its highway operations. About 2700 t (3000 tons) will be generated each year.

6. Scrubber sludge and fluidized-bed ash-limestone wastes will be disposed of in an Illinois EPA licensed commercial landfill. An EPA permit will be required to dispose of the ash.

7. A separate study has shown that during the period between the initial coal conversion and the installation of the pollution-control equipment on Boiler No. 5 (a period necessary for equipment construction and delivery), there will be no violation or contribution to violation of any primary National Ambient Air Quality Standard by the uncontrolled emissions of Boiler No. 5. ANL is in an area that is presently "nonattainment" for secondary TSP standards. In view of that fact, DOE has filed for a delayed-compliance order with the USEPA and a variance from the Illinois Pollution Control Board to burn medium-sulfur (1.47% S) coal without control equipment until such equipment is installed. DOE will be notified by both agencies later in 1980 on approval of such emissions.

The combined impacts resulting from converting Boiler No. 5 to coal and instal lation of a fluidized-bed combustion unit in place of Boiler No. 1 will be within the Prevention of Significant Deterioration guidelines on SO_2 set in the Clean Air Act Amendments of 1977. There will be no violations of National Ambient Air Quality Standards. After retrofitting a dry-sulfur-dioxide scrubber and baghouse on Boiler No. 5, the particulate and sulfur-dioxide emissions will comply with all applicable federal and state standards. The fluidized-bed combustion unit will also meet all emission standards.

8. Water runoff from the coal pile will be pumped to the existing water-treatment-plant sludge lagoon. This will permit monitoring all effluent from the coal pile and boiler-house area and assure compliance with applicable water-quality regulations.

9. The principal impact to biota and soils resulting from the proposed action will occur during the construction of the coal-storage facility in a presently disturbed area. Construction of the facility would result in the destruction of a very small part of the old-field plant community and loss of small-animal habitat and fallow-deer forage that presently exists at the proposed site.

Increased SO_2 emissions resulting from the combustion of coal at the ANL boiler plant may be sufficient to cause transient changes in the physiological and/or biochemical processes of exposed plants during periods of plume downwash. However, the duration and frequency of downwash episodes are not expected to be sufficient to cause permanent damage to vegetation.

No coal- or combustion-waste products will be directly released into any existing aquatic resource.

10. Traffic congestion may result if coal and limestone are transported onto the site by truck. However, rail transport would eliminate competition for road space. Also, delivery scheduled to avoid rush hours would alleviate congestion.

During the initial period (about 1 year) when emission-control devices for Boiler No. 5 are not in operation, the stack plume may appear more opaque and more noticeable to residents of neighboring areas. Subsequent installation of the air-pollution-control equipment would tend to remedy the visibility problem.

11. Alternative fuels and burning methods have been examined, and it is concluded that the processes selected should provide the best fuel use and protection of the environment consistent with economic and legal requirements and commercial availability.

associated with emissions resulting from the combustion [illegible]

[illegible]

[illegible]

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1. PURPOSE AND NEED FOR THE ACTIONS

The boiler plant at ANL consists of five gas/oil-fired boilers that provide the steam requirement of the entire Laboratory. The subject of this environmental assessment is the conversion of Boiler No. 5 to high-sulfur-coal firing and the replacement of Boiler No. 1 with an atmospheric fluidized-bed combustion unit to burn coal. At present, Boiler No. 5 burns natural gas exclusively and supplies about 58% of the annual ANL steam requirement. The average total steam production from the entire ANL boiler plant is about 59,000 kg/h (130,000 lb/h) and the maximum production is 122,000 kg/h (270,000 lb/h). The unit to replace Boiler No. 1 will have a steam capacity of 45,000 kg/h (100,000 lb/h). With the planned conversion and replacement, burning of 50,000 t (55,000 tons) of high-sulfur coal each year will replace the consumption of about 3.5×10^7 m^3 (1.22×10^9 ft^3) of natural gas and about 2900 m^3 (760,000 gal) of fuel oil.

Burning of relatively abundant coal has the beneficial effect of saving oil and natural gas, which are much less abundant resources. In addition to being part of ANL's energy-conservation program, the proposed action of converting Boiler No. 5 to coal firing is also being implemented to comply with a proposed prohibition order (for Boiler No. 5 to stop burning oil and natural gas) issued on 12 September 1979 by the Economic Regulatory Administration under the Fuel Use Act of 1978 (Public Law 95-620). On the other hand, combustion of coal would result in emission of certain pollutants and in other environmental impacts if control measures were not undertaken.

Therefore, this environmental assessment is prepared as a planning document that evaluates relevant environmental issues, so that these may be factored in a timely manner into all management decisions. The major activities related to conversion of Boiler No. 5 that are covered are (1) the rehabilitation and preparation of the boiler for coal firing, (2) the repair and upgrading of coal-handling/storage systems for safe and efficient operation, and (3) the procurement and installation of particulate- and sulfur-removal systems to meet applicable EPA and state standards. Rehabilitation of Boiler No. 5 is scheduled to proceed so as to allow burning of coal by 1 November 1980 at the earliest. Detailed specifications for the atmospheric fluidized-bed combustion unit are still being finalized, and replacement of the old Boiler No. 1 is scheduled for the winter of 1982 at the earliest.

During a period of about one year while air-pollution-control equipment is being delivered and installed, either medium-sulfur (1.47%) low-ash (7.6%) or low-sulfur (0.72%) low-ash (6.0%) coal will be burned depending on Illinois regulatory agency rulings.

2. ALTERNATIVES, INCLUDING THE PROPOSED ACTIONS

2.1 ALTERNATIVES FOR BOILER NO. 5

The purpose of Boiler No. 5 and the rest of the steam plant is to provide steam for various uses at ANL. The major use is for space heating, with refrigeration (air conditioning) and emergency electric-power generation as secondary needs. The available alternatives for providing for these needs are as follows:

1. No action; continue as at present burning natural gas and fuel oil in Boiler No. 5 and other boilers.

2. Refurbish Boiler No. 5, repair and reactivate the present coal-handling and -burning equipment, and burn high-sulfur coal. SO_2 scrubbers and improved particulate-removal equipment will be required. Oil or gas would continue to be used as supplemental fuels in Boilers No. 1, 2, 3, and 4.

3. Same as above except low-sulfur coal would be burned. The SO_2 scrubbers would be smaller in capacity than for high-sulfur coal.

4. Use alternative coal-burning methods such as fluidized-bed combustion, or burn some form of chemically transformed and cleaned coal.

5. Decentralize the system and use electrical heat, heat pumps, local total-energy systems, or solar heat.

These alternatives are discussed in the following sections.

2.1.1 No Action

At present, Boiler No. 5 burns natural gas exclusively and supplies about 58% of the annual ANL steam needs. The plant-average total steam production is about 59,000 kg/h (130,000 lb/h) and the maximum production is 122,000 kg/h (270,000 lb/h). The amount of natural gas burned is limited by an allotment from the utility company, which in 1979 was raised from 43,340 therms per day to 55,000 therms per day (1 therm = 1×10^5 Btu = 1.055×10^8 J). The combustion of 1 m^3 (35 ft^3) of the purchased gas generates about 3.7×10^7 J (3.5×10^4 Btu) and about 2.9×10^6 J (2750 Btu) are required to produce 1 kg (2.2 lb) of steam.

For steam requirements greater than can be supplied by the daily gas allotment, No. 2 (distillate) fuel oil is burned in one or more of the other boilers. In 1978, ANL consumed 3.5×10^7 m^3 (1.22×10^9 ft^3) of natural gas and 2900 m^3 (760,000 gal) of No. 2 fuel oil. The energy equivalents were 1.3×10^{15} J (1.20×10^{12} Btu) from gas and 1.11×10^{14} J (1.05×10^{11} Btu) from oil (3.85×10^{10} J/m^3 or 1.38×10^5 Btu/gal heat equivalent of oil). Using the current allotment for a maximum steam demand of 122,000 kg/h (270,000 lb/h), 83,000 kg/h of steam will be supplied by 6.62×10^3 m^3/h of natural gas, and 39,000 kg/h of steam by 2.9 m^3/h of fuel oil. The present allotment of gas can provide sufficient steam for all except the most severe weather conditions.

The gas is essentially sulfur free, but the sulfur content of the oil is 1.7 kg/m^3. The SO_2-emission rate for oil burning is 88 ngm/J, well below the EPA standard of 340 ngm/J for liquid fossil fuels. NO_x emissions from Boiler No. 5 range from 60 to 110 ppm depending on the load. The EPA standard for a new gas-burning source is 170 ppm. No visible particulates or bulk ash are produced by the system.

2.1.2 Conversion to Coal

2.1.2.1 High-Sulfur Coal (The Proposed Action)

The proposed burning of high-sulfur Illinois or eastern coals would necessitate use of the coal-handling and -burning equipment now in place. In order to use this equipment, repairs and modifications would be needed along with some entirely new components, primarily flue-gas-cleaning systems now required by federal and state clean-air laws for any new coal-burning installation.

The major new components for flue-gas-cleaning are a scrubber for SO_2 and a baghouse for particulate removal. These systems are described in Section 2.4.1. Repairs, modifications, and additions must also be made to the coal-storage and -reclaiming systems. The locations of the pre-1965 coal-storage piles are now occupied by a new facility and the oil-storage tanks. Consequently, a new coal-storage area will have to be developed and a new conveyor built to serve the storage area. The old system of conveyors, used for transporting coal from railroad cars to storage to crusher to boiler, had little or no dust-control equipment, which will now be required. In addition, safety devices (guard rails, cutoff switches, etc.) must be installed and general repairs made. Modifications must be made to handle currently mined coals, which are generally of different particle-size specifications than those previously used. Further details of the coal-transport, handling, and storage alternatives are contained in Section 2.4.2.

The specifications for Boiler No. 5 call for a maximum steam production of 77,000 kg/h (170,000 lb/h) and an average of 39,000 kg/h (85,000 lb/h). At these rates the coal use will be 8.2 t/h (9.0 tons/h) maximum, and 3.7 t/h (4.1 tons/h) or 35,000 t/yr (40,000 tons/yr) average. The heat of combustion of the coal will be about 3.0×10^7 J/kg (1.3×10^4 Btu/lb).

The probable fuel will be Illinois No. 6 coal, although other eastern coals may also be used. Typical specifications for the fuel are given in Table 2.1. The exhaust gas is expected to have the volume-fraction composition shown in Table 2.2. The equivalent of about 3.5×10^{14} J (3.3×10^{11} Btu) will continue to be supplied by natural gas or oil.

About 1300 t (1400 tons) of bottom ash and 2400 t (2600 tons) of fly ash will be produced each year. About 90% of the fly ash (2200 t or 2400 tons), primaril of the larger sized particles, will be caught in the cyclones and the remainder caught in the baghouse and scrubber. A maximum of 45 t/yr (50 tons/yr) (0.04 kg/billion J or 0.1 lb/million Btu) will be released to the atmosphere.

Table 2.1. Approximate Specifications of Illinois No. 6 Coal[a]

Heat value (high)	12,600 Btu/lb
Ash	10%
Moisture	10%
Sulfur	3.6%
Carbon	61.1%
Hydrogen	5.8%
Oxygen	9.1%
Nitrogen	1.1%
Chloride	0.1% max

[a]From "ANL Bid Specifications for Emissions Control System," 1980.

Table 2.2. Expected Flue-Gas Composition[a]

Component	Percentage by Volume
CO_2	11.09
SO_2	0.24
N_2	75.5
O_2	6.7
NO_2	0.04
H_2O	6.51
HCl	0.006

[a]From "ANL Bid Specifications for Emissions Control System," 1980.

A theoretical minimum of 4900 t (5400 tons) of calcium-sulfite sludge (on a dry basis) will be produced each year. Depending on the scrubbing process used and the operating conditions, excess lime or limestone reagent may be necessary to obtain the required degree of cleanup, and the amount may be twice (9800 t) the above. At present, most wet scrubbers produce a wet sludge containing a maximum of about 15% solids, which is then dried with thickeners and vacuum filters to 50% to 75% solids.

Details on the air-cleaning devices are contained in Section 2.4.1 and details on ash and sludge handling can be found in Section 2.4.3. Boilers No. 2, 3, and 4 will be unaffected by the conversion of Boiler No. 5. Alternatives for conversion of Boiler No. 1 are discussed in Section 2.2.

2.1.2.2 Low-Sulfur Coal

The use of low-sulfur (∼ 0.7% S) eastern Kentucky coal has also been considered. This coal could meet EPA emission standards for SO_2 without scrubbers; however, particulate-removal equipment would still be required. This coal is much less abundant than high-sulfur coal and should be reserved for special uses.

The heat value of the coal would be expected to be about 3.0×10^7 J/kg (13,000 Btu/lb) compared to 2.9×10^7 J/kg (12,600 Btu/lb) for Illinois coal. As a consequence, about 3% less coal would have to be burned. The ash content of the coal would be about 6%, compared to 10% for the Illinois coal. The total ash produced using low-sulfur coal would be substantially less than that produced using high-sulfur coal.

Although low-sulfur eastern coal is obtainable, there is much less available than the relatively abundant high-sulfur coal obtainable in Illinois coal fields. Transportation costs for the Illinois coal are substantially lower, and SO_2- and TSP-emission specifications can be met with the equipment to be installed. Thus, high-sulfur coal is preferred. During the period when Boiler No. 5 control equipment is being installed, a low- or medium-sulfur low-ash coal will be used as directed by state regulatory agencies.

2.1.2.3 Fluidized-Bed Combustion for Boiler No. 5

Several alternatives to the standard methods of burning coal in stoker-fed or pulverized-coal furnaces now exist or will in the near future. In the fluidized-bed combustor, a mixture of ground limestone and coal is burned in a bed kept fluidized (suspended) by a stream of air blowing through a grid at the bottom of the combustor. The SO_2 produced combines with the limestone and is removed continuously by bleeding off partially sulfated limestone, which also keeps the level of the bed constant.

A relatively low combustion temperature (1300°F-1800°F) minimizes the production of NO_x and suspending the boiler-water tubes in the burning bed provides a high and efficient rate of heat transfer. A baghouse or electrostatic precipitator must be used to remove particulates in the flue gas.

The process is in a very early stage of commercial development; however, several small units are currently in use. Extensive remodeling would be required to use this system in Boiler No. 5, and it is doubtful that the conversion would be economical or practical. However, as described in Section 2.2, plans are being made to replace the 30-year-old Boiler No. 1 with an entirely new 45,000-kg/h (100,000-lb/h) steam capacity, atmospheric fluidized-bed boiler. The new Boiler No. 1 and the converted Boiler No. 5 could provide nearly the total steam requirement for ANL.

2.2 ALTERNATIVES FOR BOILER NO. 1

Alternatives to the replacement of Boiler No. 1 include any of the actions described in Section 2.1. In addition, the following alternatives can be considered:

1. Conversion of Boiler No. 1 to grate-fired coal capacity. Scrubbers and particulate-removal equipment would be necessary.

2. Replacement of Boiler No. 1 by an atmospheric fluidized-bed combustion facility (the proposed action).

The oil- or gas-burning Boilers No. 2, 3, and 4 would be used during maintenance or emergency outages of the coal boilers or during extremely cold weather.

2.2.1 Grate-Fired Coal Capacity

The original grates have been removed from Boiler No. 1, hence, an entirely new set of grates would have to be installed. Also, SO_2 scrubbers and a baghouse similar and in addition to those to be installed in Boiler No. 5 would be necessary. However, Boiler No. 1 is 30 years old, the oldest ANL boiler, and the economics of large expenditures on it would be questionable.

2.2.2 Fluidized-Bed Combustion (The Proposed Action)

In the proposed action, a new 45,000-kg/h (100,000-lb/h) steam capacity boiler is to be built to replace the existing 39,000-kg/h (85,000-lb/h) Boiler No. 1. At present it is expected that Illinois No. 6 coal is to be burned in an atmospheric fluidized-bed combustion chamber. The coal and coal-handling equipment already available or to be installed for the Boiler No. 5 conversion will be used, and also the ash-handling equipment now installed will be usable. New equipment (in addition to the boiler) will be limestone-storage equipment, grinding and handling equipment, mechanical (cyclone) dust separators, and a baghouse dust separator. A separate SO_2-scrubbing system is not required.

As stated in the alternatives to the conversion of Boiler No. 5, the fluidized bed operates by passing an airstream through a mixture of ground limestone (95% by weight) and coal (5% by weight) so that the coal is burned in suspension. The SO_2 released reacts with the hot limestone and with oxygen to produce calcium sulfate (gypsum) as the end product. Coal and limestone are fed in separate streams; the coal is removed by burning and the bed is bled off to remove calcium sulfate and ash (the rapid consumption of coal in the bed keeps the coal fraction at a low value). Two sets of cyclones and a baghouse remove particulates from the flue gas. For efficiency, some of the particulate material is recycled into the combustion area. A low combustion temperature minimizes NO_x production, and the limestone can achieve 90% SO_2 removal.

At full capacity, the boiler will use 5605 kg/h (12,360 lb/h) of Illinois No. 6 coal and 2130 kg/h (4700 lb/h) of limestone. About 1700 kg/h (3750 lb/h) of mixed ash and sorbent will be discharged from the fluidized bed, about 506 kg/h (1115 lb/h) from the cyclone separators, and 57 kg/h (125 lb/h) of fine particulates from the baghouse. Assuming that over a year the boiler will operate at half capacity, 24,000 t (27,000 tons) of coal and 9300 t (10,300 tons) of limestone will be used, and 7400 t (8200 tons) of bed ash, 2210 t (2440 tons) of coarse fly ash and sorbent, and 250 t (275 tons) of fine fly ash and sorbent will be produced each year.

The flue-gas discharge will contain about 3.4 g/billion J (0.008 lb/million Btu) of particulate matter, which is equivalent to 0.01 g/m^3 (0.005 $grain/ft^3$), and 0.25 kg/billion J (0.6 lb/million Btu) of SO_2. The ash and particulates from each source will be combined and stored in an existing ash silo and transported offsite for disposal or trucked to the onsite landfill. A schematic flow diagram of the process with a detailed material balance is shown in Figure 2.1.

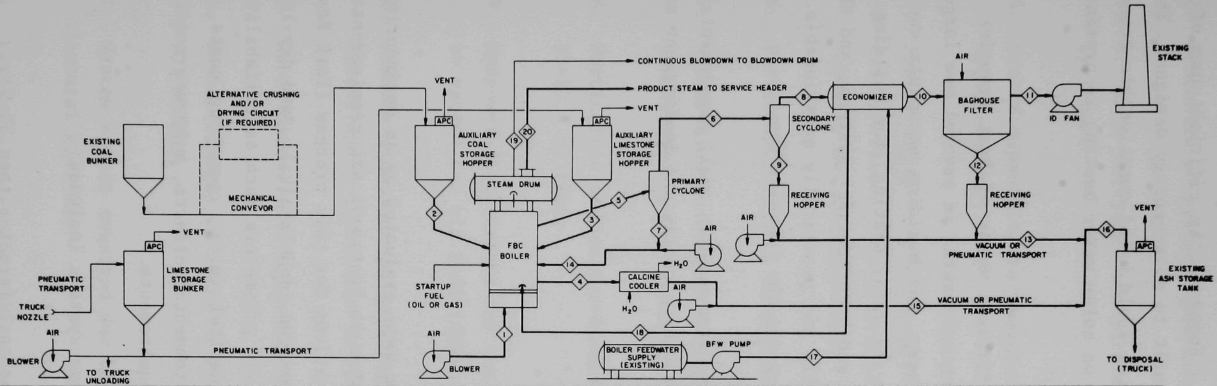
2.3 OTHER ALTERNATIVE ENERGY USES

2.3.1 Refined Coals

Processes are now under development in which coal may be dissolved in organic solvent, cleaned of ash and sulfur, and reconstituted as a solid, or be converted to a clean liquid or a gas. Although these processes offer the possibility of the environmentally clean use of coal, they are not yet commercially available.

2.3.2 Decentralized Heating

The potential exists for energy saving by using small local heating units in each ANL building. In general, coal cannot be efficiently or cleanly burned in such small units and fuels that are relatively scarce such as gas, liquified petroleum gas, or oil would be required.



MATERIALS BALANCE

		COMPONENT	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	WET GAS, lb/hr	NITROGEN (N_2)	94,298				94,438	94,438		94,438		94,438	94,438		119	477	360	479				
2		OXYGEN (O_2)	28,486				4,079	4,079		4,079		4,079	4,079		36	142	108	144				
3		CARBON DIOXIDE (CO_2)					28,678	28,678		28,678		28,678	28,678									
4		SULFUR DIOXIDE (SO_2)					92.7	92.7		92.7		92.7	92.7									
5		WATER (H_2O)	847				7,602	7,602		7,602		7,602	7,602		1	4	3	4	105,000	105,000	5,000	
6		STEAM																				100,000
7																						
8		TOTAL WET GAS, lb/hr	123,631				134,890	134,890		134,890		134,890	134,890		156	623	471	627	105,000	105,000	5,000	100,000
9	SOLIDS, lb/hr	MOISTURE (H_2O)		1,730	188																	
10		COAL (MAF)		9,373																		
11		ASH		1,258	179	1,074	1,778	356	1,422	36		36	0.4	36	356	1,422	1,074	1,430				
12		CHAR				56	93	18	74	2		2	—	2	18	74	56	74				
13		CALCIUM CARBONATE ($CaCO_3$)			4,342																	
14		CALCIUM OXIDE (CaO)				1,280	2,118	424	1,695	43		43	0.4	43	424	1,695	1,280	1,704				
15		CALCIUM SULFATE ($CaSO_4$)				1,333	2,205	441	1,764	44		44	0.5	43	441	1,764	1,333	1,774				
16		TOTAL SOLIDS, lb/hr		12,361	4,710	3,743	6,194	1,239	4,955	125	1,115	125	1.3	124	1,239	4,955	3,743	4,982				
17		TOTAL STEAM, lb/hr	123,631	12,361	4,710	3,743	141,084	136,129	4,955	135,015	1,115	135,015	134,891	124	1,395	5,578	4,214	5,609	105,000	105,000	5,000	5,000
18																						
19																						
20																						
21																						
22																						
23	CONDITIONS	PRESSURE, psig (ins H_2O)	(40)	(0)	(0)	(20)	(3)	(9)	(9)	(18)	(18)	(24)	(28)	(28)	(15)	(0)	(20)	(18)	270	215	200	200
24		TEMPERATURE, F	200	60	60	1,550	780	770	770	760	760	400	400	400	450	600	350	350	230	340	388	388
25		GAS FLOW RATE, SCFM @ 60 F AND 14.7 psia	26,937	—	—	—	28,904	28,904	—	28,904	—	28,904	28,904	—	34	135	102	136		—	—	3,638 cfm
26		GAS FLOW RATE, ACFM @ TEMP & PRESSURE	34,189	—	—	—	68,925	68,370	—	67,813	—	47,803	47,800	—	—	—	—	—	210 gpm	210 gpm	—	—
27		PARTICULATE LOADING, gr/SCF	—	—	—	—	20-30	4-6	—	0.4-0.6	—	0.4-0.6	0.004-0.006	—	—	—	—	—			—	—
28		GAS MOLECULAR WEIGHT	29.0	—	—	—	29.5	29.5	—	29.5	—	29.5	29.5	—	29.0	29.0	29.0	29.0	—	—	—	—
29																						
30																						
31																						
32																						

Figure 2.1. Materials-Flow Diagram - Fluidized Bed.

The use of solar heating is a possibility. However, the efficient use of solar energy generally requires buildings built to solar-energy designs. The conversion of older buildings to solar heating would be of questionable economic value or energy saving. A research project on solar water heating is presently being conducted at the ANL cafeteria.

Electrical heating using heat pumps and efficient means of heat transfer between different building sections has been successful in several new large buildings. Excess heat from lights, machinery, and building occupants can often provide much of the heat needed. As for solar heating, the buildings should be originally designed for heat-pump and heat-transfer systems, and the conversion of older buildings is economically and practically questionable. Large capital expenditures would be necessary for the installation.

Direct resistance heating by electricity is often used in small supplemental heating units. The use in large systems would be a costly and inefficient use of electricity.

2.4 ALTERNATIVE MITIGATION MEASURES

2.4.1 Scrubbing Systems

Four flue-gas-desulfurization (FGD) systems were evaluated by an engineering consulting firm to recommend a process system to best meet ANL requirements and to limit the scope of the bid specifications for this process (York Res Corp 1980). The systems--wet-lime, wet-limestone, double-alkali, and dry-lime scrubbing--were evaluated relative to specific parameters such as reliability, degree of commercialization, technology, capital costs, operating costs, high-sulfur-coal capability, secondary environmental effects, manpower requirements, standards flexibility, and reheat requirements.

The list of criteria used in evaluating these systems includes:

1. System capability to handle high-sulfur coal (greater than 3% S);

2. Demonstrated system capability to achieve over 90% reliability;

3. At least one-year demonstrated commercial operating experience with the system;

4. System capability to operate in the closed-loop mode with minimum water requirements;

5. System capability to comply with a sulfur-dioxide-emission limit of 0.5 kg/billion J (1.2 lb/million Btu) of actual heat input and an outlet capacity not to exceed 30%;

6. Particulate control accomplished with a baghouse;

7. Sulfur-dioxide control accomplished with a wet-lime, limestone, double-alkali, or dry-lime system;

8. Particulate and sulfur-dioxide systems to cost no more than the budgeted \$3-\$3.5 million;

9. Manpower requirements for the operation and maintenance of the system not to exceed the six individuals previously allocated by ANL;

10. Offsite limestone pulverizing/processing permitted, in view of the relatively small quantities involved;

11. Waste removal (sludge) accomplished by trucking to an offsite location;

12. Waste (sludge) to be in as dry a form as possible, consisting of at least 70% solids;

13. System bypass required due to boiler capability of burning either oil or natural gas; and

14. Fail-safe operation such that, in the event of an emergency, the bypass damper (around the system stack) will permit gases to be exhausted directly to the stack.

The wet-lime process is a nonregenerative, throwaway FGD process in which SO_2 is removed from the flue gas by wet scrubbing with a slurry of calcium oxide (CaO). The system operations include SO_2 absorption, solids separation/slurry thickening, and effluent disposal. A typical liquid-to-gas ratio (L/G) is 20-100 gallons per thousand actual cubic feet per minute (gal/1000 ACFM) depending on the type of contactor (venturi scrubber, spray tower, packed tower, or mobile bed absorber). The effluent is directed to a hold tank for precipitation of calcium sulfite and calcium sulfate. The hold-tank effluent is dewatered in a thickener to increase the solids content to about 25%-40% by weight. Additional dewatering (60%-75% solids concentration) can be achieved by vacuum filtration. Sludge disposal is the major drawback of the "throwaway" FGD systems. The quantity of sludge produced can be relatively large in weight and volume, requiring considerable cost for ultimate disposal.

The wet-limestone-slurry process is also a nonregenerative, throwaway FGD process, but the SO_2 is removed from the flue gas by wet scrubbing with a slurry of calcium carbonate ($CaCO_3$). The operations are very similar to those in the wet-lime process. The sludge in the limestone process usually has a faster settling rate than does that in the lime-slurry process.

The double-alkali process is a regenerable FGD process that removes SO_2 from the flue gas by wet scrubbing with a sodium-sulfite liquor. A waste sludge of calcium sulfite is formed, as is a regenerated scrubbing liquor of sodium sulfite. The scrubber type is a two-stage tray or packed-tower absorber with an L/G of 10-20 gal/1000 ACFM (USEPA 1979). In this process the amount of soluble and slurried calcium in the scrubber is minimized, thus offering the opportunity for decreased-scale potential. This is one of the most widely used regenerable FGD processes currently applied on a commercial scale.

The SO_2 is absorbed into a sodium-hydroxide/sodium-sulfite scrubbing solution in an absorption tower. The effluent is regenerated with lime or limestone in a reaction tank. The waste produced is composed primarily of insoluble solids, particularly calcium sulfite, calcium sulfate, and some calcium carbonate. Sodium salts may constitute as much as 5% of the filter cake; therefore, direct landfill of the waste is less attractive due to the potential of high sodium concentration in the leachate.

Primary differences between these three processes and the dry-lime scrubbing process is that in the dry process (1) the solvent is atomized and sprayed into the flue gas at a rate that will not saturate the air; (2) the particulate-collection device is placed downstream of the FGD, because the water droplets evaporate and only a dry powder is left; (3) a much lower L/G is used, 0.2 to 0.4 gal/1000 ACFM; (4) no reheat of the exit gas is required, because the temperature of the flue gas is still well above the acidic dewpoint; (5) no mist eliminators are needed; (6) a much smaller quantity of waste must be disposed of; and (7) capital and operating costs are lower.

2.4.2 Coal-Transport, Handling, and Storage Facilities

2.4.2.1 Transport

Coal will be bought from local (Chicago-area) vendors having storage yards within 40 km (25 mi) of ANL. These yards will probably receive coal transported from the mines by barge. Delivery of the coal to ANL will be by 30- to 40-ton trucks. A maximum of three to four truckloads per day would be delivered.

The option for railcar delivery to ANL is to be left open. Repairs and upgrading will be necessary to accommodate modern 100-ton-capacity coal cars.

2.4.2.2 Coal Handling

Coal handling involves removing the coal from the railroad car or truck, transferring the coal through the crusher either to the boiler house or to the storage piles, and reclaiming from the storage pile. In the original ANL system, an enclosed conveyor led from the car-dumping house to the coal-crusher building, and from there a second enclosed conveyor led to the boiler house. Two short open conveyors led from the crusher building to nearby points where coal was conveyed by mobile equipment (front-end loaders or bulldozers) to the final storage pile.

Inasmuch as the original storage areas are now occupied, new areas must be developed that will require a new stocking and reclaiming system. Final designs for the new system have not been finished. However, it will probably have a short conveyor leading eastward from the car-dumping house, and possibly a second movable conveyor. Mobile equipment will be used for forming the coal piles. A foam dust-suppression system will be used at transfer points, stockpiles, and other points where covering is not feasible. The foaming agent is a proprietary formula that is stated to be nontoxic and biodegradable.

Coal will be reclaimed by mobile equipment and transferred to hoppers at the car-unloading house for transfer to the conveyor system. Dust controls will be added to the present system, as will a number of safety features such as emergency exits, belt and chain guards, handrails, and emergency shutoff switches.

Alternatives to the proposed system that have been considered include a covered-conveyor system 100 m (300 ft) long from the crusher house to the deposition point and a high-level conveyor that would dump coal directly onto the storage piles. The use of underground hoppers and conveyors under the coal piles for direct reclamation is not being considered at ANL because of the large costs involved.

In general, the alternatives differ primarily in economics rather than environmental effects. Dust controls would be necessary in any case, but only minor differences in environmental effects would exist.

2.4.2.3 Coal Storage

A coal-storage yard for the heating plant will be provided east of the present railroad tracks and car-unloading building. About 18,000 t (20,000 tons) or about a four-month reserve, will be stored within the roughly 1.3-ha (3.2-acre) area shown in Figure 2.2. The yard will be developed above the floodplain, which reaches to 201 m (660 ft) MSL, and no effects on the floodplain should occur other than inadvertent ones during construction. A berm at the 203-m (665-ft) level will be extended from the existing embankment at Sawmill Creek to the existing railroad ramp. The berm (compacted to decrease its permeability) will essentially seal off the depicted coal-storage watershed from the floodplain. The coal-storage area at the 202-m (662-ft) level will be graded and compacted to reduce soil permeability, with drainage ditches on two sides

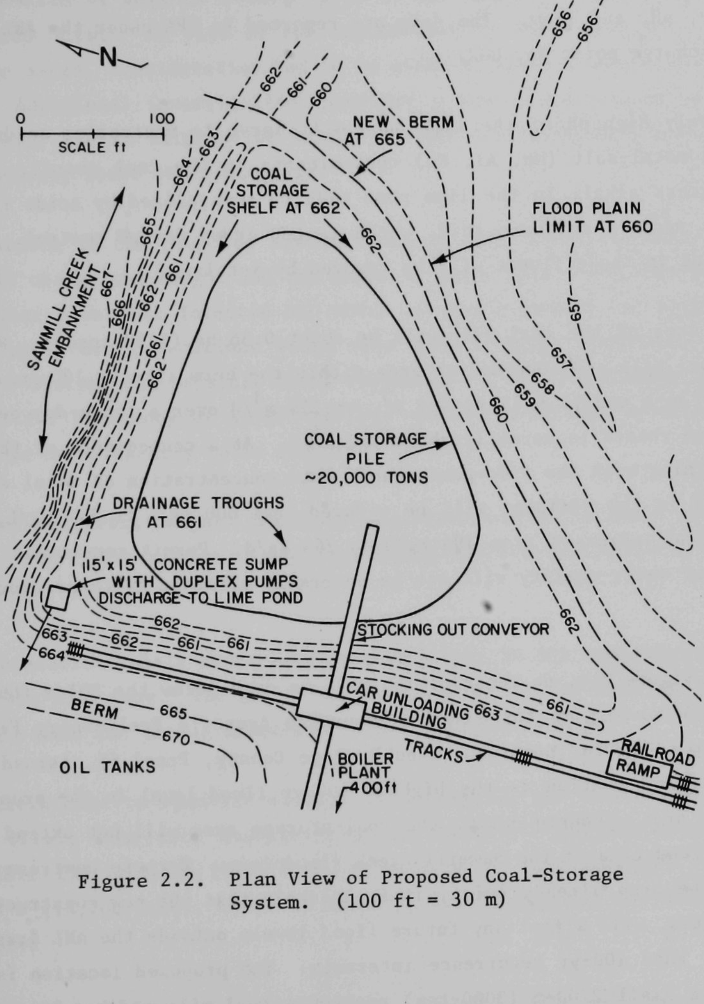


Figure 2.2. Plan View of Proposed Coal-Storage System. (100 ft = 30 m)

to permit runoff water to flow to a concrete collection sump in the northwest corner of the triangle. Rainwater runoff will be collected in the sump and pumped to an existing water-treatment lime pond about 150 m (500 ft) to the west. The lime-pond runoff and boiler-blowdown water are presently combined and monitored, before discharge, for suspended solids, total solids, phosphorus, temperature, pH, and flow. The data are reported to EPA under the ANL NPDES permit, discharge point No. 002.

The relatively high pH of the lime pond will serve to neutralize acids and precipitate metal-salt (Mn, Al, Ca) contaminants in the coal runoff. Conversely, excess alkali in the lime pond will be neutralized by acids in the runoff that replace sulfuric acid, which is now added for pH control. Suspended solids in the effluent will be removed by settling.

The actual area of the coal pile will be about 0.56 ha (1.38 acres). Runoff from the coal pile and surrounding area within the berm after a 100-mm (4-in) rain (10-yr 24-h event) will be 462 m^3, or 154 m^3/d over a three-day period. The lime-pond runoff is normally about 322 m^3/d. As a consequence of the coal runoff combining with the lime-pond runoff, the concentration of total dissolved solids (TDS) in the effluent will be reduced from 600 mg/L to 552 mg/L, and the total load increased from 193 kg/d to 263 kg/d. Permit requirements and Sawmill Creek water quality will not be adversely affected by these discharge changes.

As shown in Figure 2.2, no construction will be done below the 201-m (660-ft) elevation. According to the Federal Insurance Agency's Preliminary Flood Insurance Rate Map for unincorporated Du Page County, Panel 65, issued in June 1980, that elevation is the highest 100-yr flood level in the proposed coal-storage area. Consequently, the coal-storage area will not extend into the 100-yr-flood area of the Sawmill Creek floodplain. Because upstream dikes protecting the area already exist, it is unlikely that the new construction, including dikes, will affect any future flood levels outside the ANL area that have greater than 100-yr recurrence intervals. The proposed location is now occupied by a small 2700-t (3000-ton) emergency coal pile and has been used for other storage purposes.

For long-term storage, the surface of the coal pile will be compacted and sealed with fine coal to minimize penetration of air and water.

An alternative coal-storage area occupying about 3 ha (7 acres), including the selected site as well as a large area of the Sawmill Creek floodplain, was considered first. In view of the impingement on the floodplain and small wetlands areas, consideration had to be given to other less damaging alternatives. Additional investigations provided a more definitive location of the floodplain, and an alternative design permitted location of the coal-storage area entirely above the floodplain.

Alternatives to the proposed system would put coal piles at other locations, or would change the height and the shape of the piles. Alternative areas near the boiler plant are forested and their use would involve the destruction of vegetation. Other locations would also involve large investments for new conveyor systems and possibly track relocations. The oil-storage tanks are to be kept for emergency or severe-weather use of oil because Boilers No. 2, 3, and 4 are not presently to be converted to coal.

Piles of different heights and shapes would be similar in their environmental effects but differ mainly in the engineering and economic costs of coal handling (Considine 1977).

An impermeable asphalt surface is an alternative to the compacted ground to be used as a pile base. The generally low permeability of the local soils would probably make the use of impermeable barriers unnecessary.

The alternative to open-air storage is storage of the coal in enclosed concrete silos; some with capacities up to 360,000 t (400,000 tons) are now available (Rittenhouse 1979). Silos with about the required capacity, 13,000 t (14,000 tons), would be about 55 m (178 ft) high and 29 m (95 ft) in diameter.

The silo has the obvious environmental advantages that no runoff would occur and that dust is controlled. In addition, the coal would be protected from weathering and be easily reclaimable in freezing or otherwise inclement weather when reclaiming outdoor coal might be difficult.

A silo at ANL would entail a large expenditure of money as well as the waste of a large amount of equipment now available. It should be noted that silos are generally used for short-term ready storage rather than long-term storage.

2.4.3 Waste-Disposal Techniques

2.4.3.1 Ash-Handling System

The proposed ash-handling system will be basically a remodeled and upgraded version of the original system. The bottom ash from the grate and fly ash collected in the cyclones will be transported dry, by a vacuum system, to an existing silo for temporary storage before removal. As noted earlier, about 1300 t (1400 tons) of bottom ash and 2200 t (2400 tons) of fly ash will be produced each year. Of the latter, about 135 t (150 tons) of fine fly ash will be collected in a baghouse and mixed with dry-scrubber dust. However, if the wet-SO_2 scrubber alternative is selected, the baghouse will be placed before the scrubber and only fly ash will be collected.

The bottom ash and the fly ash collected in the cyclone are of relatively large particle size, low surface area, and composition similar to that of many glasses or clay bricks. Consequently, for most of the coal proposed for use at ANL, there would be little leaching of harmful materials from the ash.

The bottom and cyclone fly ash will be collected by the Du Page County Highway Department for use in highway operation. The material will be used primarily to improve traction in ice and snow conditions. An alternative is to dispose of the ash in the present ANL sanitary landfill. With the usual precautions of minimizing runoff by compaction and application of a clay cover, this would appear to be a satisfactory disposal method, although the ash must be analyzed and listed in the Illinois EPA permit for the landfill. Monitoring wells and a program of monitoring are presently being instituted at the landfill, in any case.

Other alternatives include the use of bottom and fly ash in cement aggregates or as inert fill (USERDA 1976). The relatively small quantities available at ANL would make commercial use unlikely.

The fine fly ash from the baghouse would have the greatest potential for possible harmful effects because, in general, many toxic trace elements are both enriched and more leachable in the finer particles (Mann et al. 1979). Leach tests should be made on this material to determine whether any special precautions would be necessary for landfill disposal. If the leachates show high levels of toxic trace elements, some form of fixation or prevention of transport by the use of impermeable membranes would be necessary. Fly and bottom ash are not considered as hazardous wastes under RCRA (40 CFR 261.4); however, disposal requirements are still under consideration by the Congress.

2.4.3.2 Scrubber Sludge

The alternatives for sludge disposal will depend on the properties of the sludge produced. The dry-scrubber system that will be used at ANL produces a dry powder, but depending on the absorbent, the entrained fly ash, and the mechanical system, the sludge can have variable amounts of leachable materials and varying physical properties.

Although the dry material is dimensionally stable, a high content of leachable substances would make it necessary to dispose of the material under conditions where water access is limited or prevented. Hence, disposal would have to be in a naturally impermeable bed, or impermeable membranes above and below the sludge would be necessary. At present, sludge from existing dry systems (mostly in the western United States) is being disposed of by open landfill dumping, and no studies on the environmental effects of dry-sludge disposal have been identified. The necessity of protection against water access for the ANL sludge would have to be determined by leach tests. The dry sludge will be temporarily stored in a silo before being trucked offsite and disposed of in a state-approved sanitary landfill. Illinois EPA permits will be required for the transfer. Discussions with commercial operators of approved landfills have indicated that sufficient capacity is available. The sludges are not presently considered as hazardous materials under RCRA regulations.

About 6400 t/yr (7000 tons/yr) of dry sludge will be produced. The range of possible volumes is between 4000 and 8000 m^3 (5200 and 10,400 yd^3), depending on the variables mentioned earlier. The main constituents will be calcium sulfate, calcium sulfite, and about 2% fly ash.

Wet-scrubber systems (alternatives to the dry system selected) initially produce a slurry of about 15% solids (Mann et al. 1979). The solids content can be raised to 30% or 40% in a thickener; however, the product remains essentially a thick liquid. The concentrated sludge can most simply be disposed of in a pond. If the soluble-solid or dissolved-trace-element content of the liquid is high, and the local soils are not naturally impermeable, the pond must be lined with a clay or synthetic impermeable layer. Water separating from the settling solids must be recycled or treated before release. Composition of typical wastewater is tabulated in Section 4.4.

In general, the settled sludge will remain wet and dimensionally unstable or thixotropic for long periods of time. The surface of the sludge will generally not support a protective earth layer, and the area will not be useful for any other purpose.

A number of alternatives to simple ponding are available (Ansari et al. 1979). The sludge can be dried by vacuum filters to 60% or 70% solids where some sludges are dimensionally stable and can be used in properly designed landfills. The sludge may be treated with various materials that will form stable solids of low permeability, suitable for landfills. Among the materials that can be used are portland cement, certain blast-furnace slags, and certain types of fly ash. The fixatives can be added to the 40%-solids sludge and the product allowed to settle and harden in place, with runoff water being recycled or treated before release. The fixative can also be added to the 70%-solids sludge and the solid material transported to the landfill where it hardens. ANL specifications for wet sludge call for a 70%-solids content, with fixation if necessary, to provide a suitably stable product.

As another alternative, the sludges can be oxidized with air, converting the calcium sulfite to calcium sulfate (gypsum), which can be easily dried and handled. However, protection of the waste from water entry must be provided.

Although the total-solids content for wet systems would be somewhat less than for dry sludge, the volume including water would probably be somewhat greater, requiring a larger disposal area. The large content of liquid and the uncertain physical properties of the wet sludge make dry sludge a significantly better environmental alternative.

References (Sec. 2)

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3. AFFECTED ENVIRONMENT

3.1 DESCRIPTION OF THE EXISTING BOILER FACILITY

Boiler No. 5 is the largest and newest of the five boilers supplying the steam requirements of ANL. The steam produced by the five boilers is used primarily for space heating, but also for refrigeration and for driving emergency electrical turbogenerators. The average total steam production is about 59,000 kg/h (130,000 lb/h), and the maximum total is 122,000 kg/h (270,000 lb/h). Boiler No. 1 is the oldest of the five boilers.

Boiler No. 5 was built by the Wickes Boiler Company (currently Combustion Engineering Company) and installed in 1965. It has a rated capacity of 77,000 kg/h (170,000 lb/h) at a gauge pressure of 1400 kPa (200 psig), which is equivalent to about 2.24×10^{11} J/h (2.12×10^{8} Btu/h). Further statistics are shown in Table 3.1. The other four boilers, also built by Wickes, were installed in 1949, 1949, 1953, and 1960, and each have rated capacities of 39,000 kg/h (85,000 lb/h). These four boilers were originally constructed to burn coal using rotograde-spreader stokers; however, in 1973, the grates were removed and replaced by burners capable of using natural gas or No. 2 to No. 6 fuel oil. Boiler No. 5 originally had both natural gas and spreader-stoker-fired coal capacity. The gas burners were replaced by combination gas and oil burners, as in the smaller boilers, but the coal grates were retained in usable form. The grates were bricked over for protection and all other coal-handling equipment was retained in mothballed form. Mechanical cyclones are in place for fly-ash removal.

At present, Boiler No. 5 burns gas exclusively but has been limited by the gas vendor to a maximum allotment of 4.572×10^{12} J/d (4.334×10^{9} Btu/d) energy equivalent, corresponding to steam production of about 65,300 kg/h (144,000 lb/h) In 1979, the allotment was increased to 5.8×10^{12} J/d (5.5×10^{9} Btu/d). For steam demands greater than can be supplied by gas, No. 2 fuel oil is burned in several of the other boilers, including No. 1.

Table 3.1. ANL Boiler No. 5 Fact Sheet

Data:	
Manufacturer:	Wickes Boiler Co.
Rated steam output:	170,000 lb/h @ 200 psig, saturated
Method of firing:	Coal/gas; oil
Fuel consumption at rated load:	
Gas @ 1000 Btu/ft^3	212,000 ft^3/h
#2 Oil @ 138,700 Btu/gal	1,528 gal/h
Coal @ 11,600 Btu/lb	9 ton/h
Start of operation:	1965
Total useful life:	35-40 yr
Remaining useful life:	25 yr
Stack-gas cleanup equipment:	Cyclones; 90% efficiency
Typical operation:	
Prior to 1973[a]	
Fuel: Natural gas	~5,460,000 therms annually (200 d/yr)
High-sulfur coal	~20,000 tons annually (165 d/yr)
Steam production:	800,000,000 lb annually
Present operation	
Fuel: Natural gas	~7,300,000 therms annually
Steam production:	~580,000,000 lb annually
Proposed operation	
Fuel: High-sulfur coal	~40,000 tons annually
Steam production:	~800,000,000 lb annually

[a]ANL boilers 1-4 were coal fired only prior to 1973. Only boiler No. 5 had the dual gas/coal-firing capability. Figures given are for 1968. During that year, the entire plant burned 44,000 tons of coal.

The boilers are housed in a red brick building (Building 108), having dimensions of 50.9 m (167 ft) x 23 m (75 ft) x 27 m (90 ft) high, which is shown in Figure 3.1. The three stacks are each 45 m (150 ft) high and 2 m (6 ft) in diameter. The tops of the stacks are 24 m (80 ft) above the roofline of the boiler building.

Associated facilities outside Building 108 are the coal-storage and -handling equipment and the oil-storage tanks. The locations of these facilities with respect to the boiler building are shown in Figure 3.2 along with several other new or proposed facilities. The coal-handling facilities include railroad tracks, a railcar-unloading structure, coal hoppers and storage areas, a coal crusher, and conveyors to transport the coal between the various areas and the storage bunkers in Building 108. A 2700-t (3000-ton) coal stockpile is available for emergency use.

For emergencies, the coal system would probably be available after about 10 days of minor repairs. For continued coal burning most of the present system could be used; however, moderately extensive modifications would be necessary.

The oil-storage facilities consist of two 1500-m^3 (400,000-gal) tanks 13 m (42 ft) in diameter and 12 m (40 ft) high. Each tank is surrounded by an earthen dike enclosing an area sufficient to hold the contents of the tank. The unloading station, tank farm, and oil-handling facilities comply with federal EPA regulations 40 CFR 112, which govern spill prevention in oil-storage facilities.

3.2 LOCATION AND TOPOGRAPHY

The boiler plant is located at the northeast corner of the ANL site, as shown in Figure 3.3. The 690-ha (1700-acre) site is located about 35 km (22 mi) southwest of the center of Chicago near the southeast corner of Du Page County, as shown in Figure 3.4. The gently rolling terrain is partially wooded and mixed former prairie, wetland, and farmland. A number of small streams and ponds are on the site. Along the southeast edge of the site is the Des Plaines

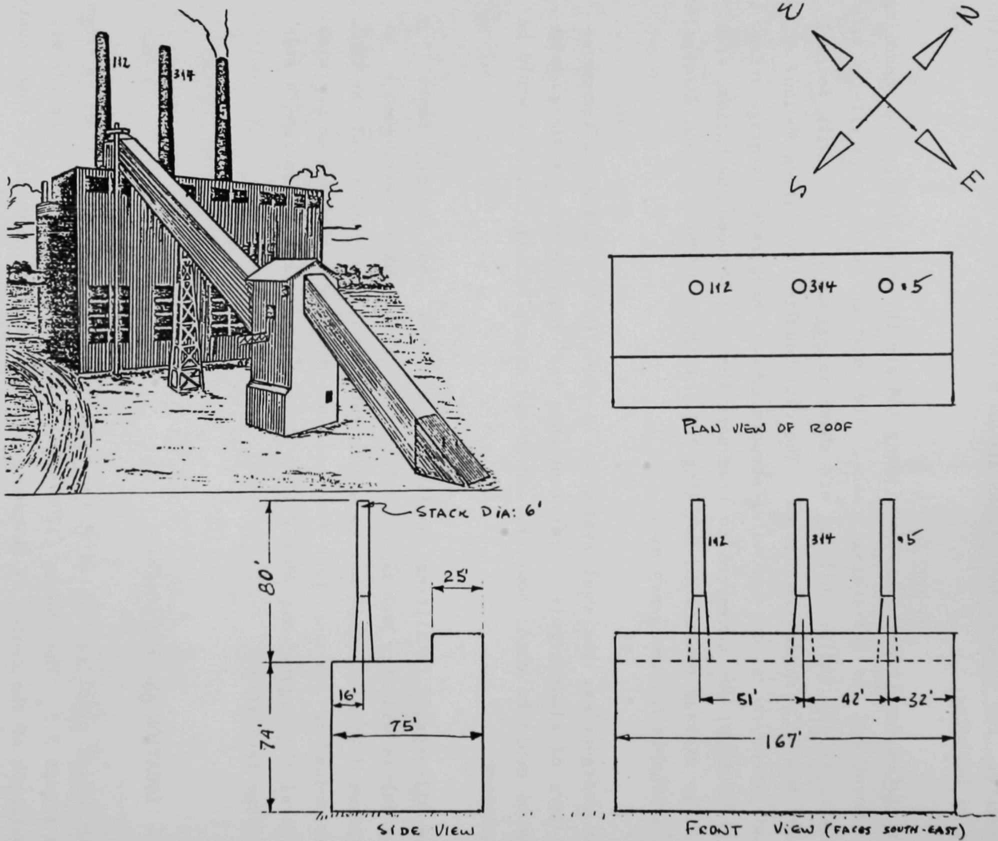
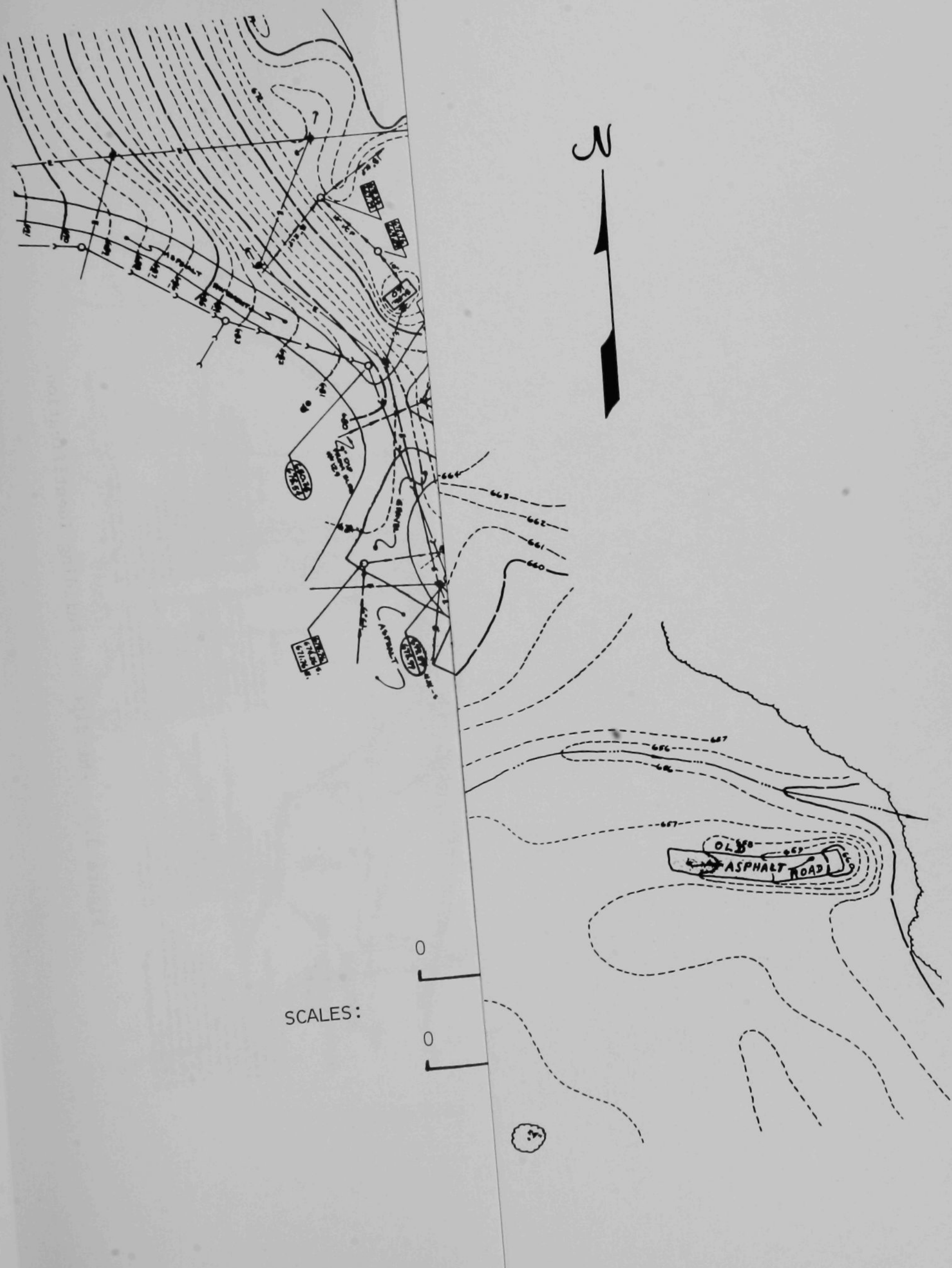


Figure 3.1. Physical Dimensions - ANL Heating Plant.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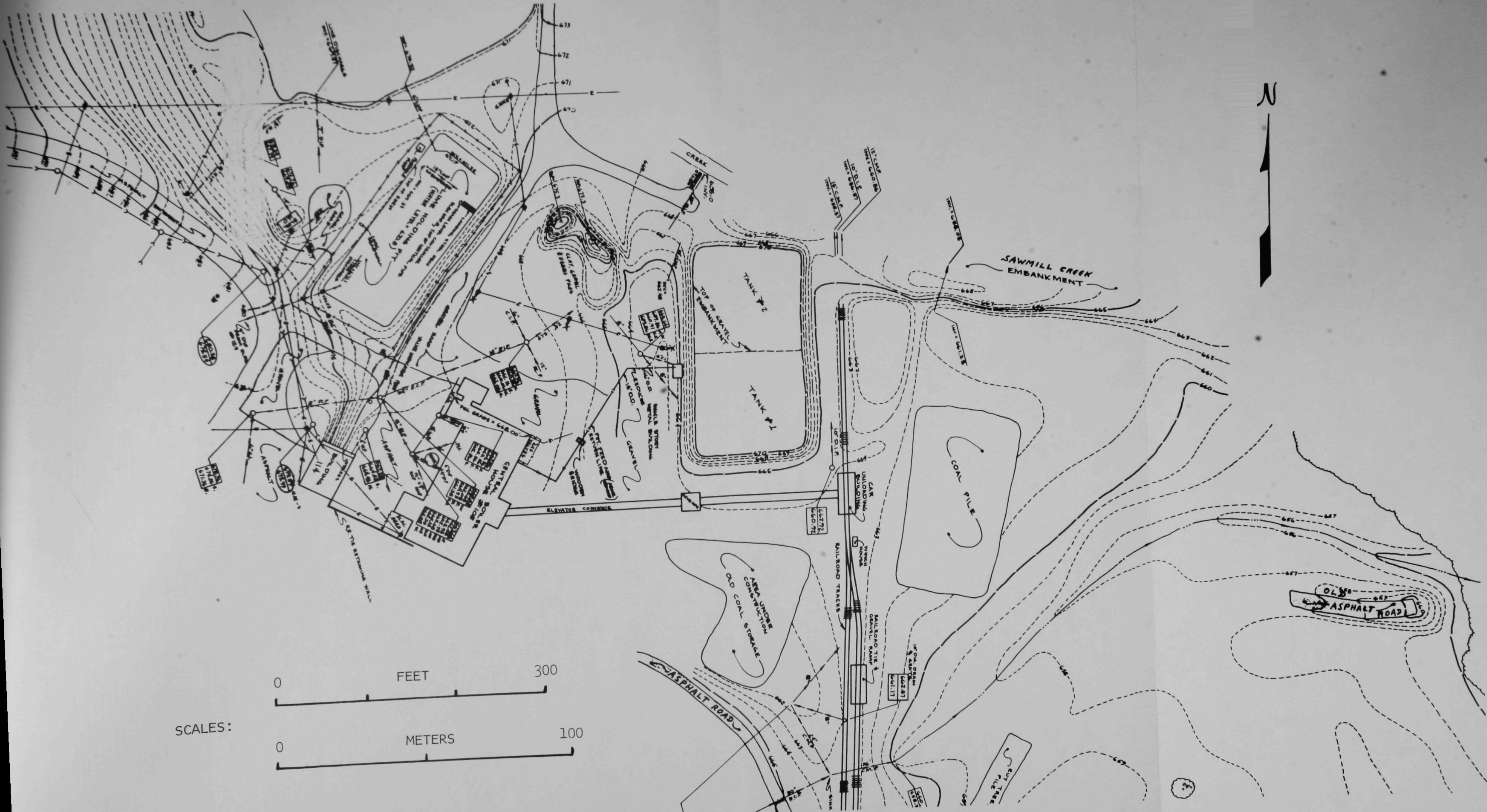

2.2. ANL Central Heating Plant Facilities.

ARGONNE
NATIONAL LABORATORY
ILLINOIS

BUILDING

2 ANL; DOE-CH
4 General Services, Plant Maintenance, Plant Systems, Procurement
5 Warehouse
6 Storage Building
8 Land Reclamation Laboratory
10 Administrative and Technical Support, Personnel
11 & 11A Environmental Impact Studies
12 Energy and Environmental Systems
14 & 19 Occupational Health and Safety
15 & 22 Argonne Center for Educational Affairs
16 Special Material, Personnel & Quality Assurance
17, 20 Central Shops
21 Security Office and Quality Assurance

BUILDING

24 Engineering
25 Training Center
33 Credit Union
91 & 92 Guard Post
108 Central Boiler House
181 Meteorology and Ecology
200 Chemistry
202 Biological and Medical Research
203 Physics & Radiological Environmental Research
205 Chemical Engineering
206 Reactor Analysis and Safety
207 SAREF Project
208 Reactor Analysis and Safety—Applied Physics
211 Cyclotron
212 Materials Science
213 Cafeteria

BUILDING

214 Engineering
221 Applied Mathematics
223 Solid State Science and the Office of the Laboratory Director
291 Guard Post
301 Laboratory Office and Storage
306 Plant Systems—Reclamation
308 & 309 Components Technology
310 EBR-II and Engineering
315 & 316 Applied Physics
330 Research Reactor (CP-5)
331 Special Materials—Division Office
333 Central Fire Station
335 Components Technology
340 Experimental Animal Quarters
350 New Brunswick Laboratory

BUILDING

360–385 Zero Gradient Synchrotron Complex
362 High Energy Physics Building and Auditorium
372 Intense Pulsed Neutron Source Program Office
373 High Resolution Spectrometer Project
583 Canal Cooling Water Treatment Plant
600–621 Lodging Facility
603 Swimming Pool
801 Accounting, Administrative Data Processing and Controller
805 Property Recycling
817 & 818 Electronics
829 Coal Liquefaction
832 Pistol Range
891 Guard Post
948 Visitors Reception Center
951 Argonne Recreation Center

Figure 3.3. ANL Site and Building Identification.

Figure 3.4. Map of Regional Area.

River Valley, a wide, shallow valley containing the river, the Chicago Sanitary and Ship Canal, and several railroads, powerlines, and industries. Dolomite outcroppings occur on the bluffs at the edge of the valley. The steam plant is in a low-lying level area of the site about 60 m (200 ft) from Sawmill Creek, a small tributary of the Des Plaines River. The site boundary nearest the steam plant is about 300 m (1000 ft) to the north (Waterfall Glen Forest Preserve), and the nearest habitation is 1.1 km (0.7 mi) to the northeast. Ground-level elevations (MSL) are 204 m (670 ft) for the steam plant, about 210 to 230 m (700 ft to 760 ft) for most of the ANL structures, and 178 m (583 ft) for the Des Plaines River. A summary of the area physiographic properties is given in Table 3.2.

Natural drainage from the boiler plant is to Sawmill Creek. Ground penetration of runoff would generally be slow and small, because the soils are clayey and the subsoils are dense clays. Sand and gravel segments of higher permeability may exist in pockets throughout the area. No construction will occur in the 100-year floodplain of Sawmill Creek.

3.3 METEOROLOGY

3.3.1 General

The regional climate around ANL is characterized as being continental, with relatively cold winters and hot summers (Denmark 1974). The area is subject to frequently changing weather as storm systems move from the Great Plains toward the east. The weather is slightly modified by Lake Michigan, which is about 35 km (22 mi) east-northeast of the Laboratory (Denmark 1974).

Weather data for 1950-1964 are available from the ANL meteorological tower (Moses and Bogner 1967) and for 1941-1970 from Chicago's Midway Airport (NOAA 1980), which is 20 km (12 mi) east-northeast of the laboratory. Long-term historical data are frequently used to describe the climate and meteorology of an area. The average daily air temperature at Argonne is 8.9°C (48.0°F); the value at Midway is 10.3°C (50.5°F). Average diurnal variations of temperature range from 7.6°C (13.7°F) in December to 11.4°C (20.6°F) in May. Table 3.3

Table 3.2. Environmental Setting - Physiography

Parameter	Description
Elevation, ANL site	700-750 feet MSL for several miles north and east of site.
Elevation, Des Plaines River south of ANL	583 feet MSL.
Elevation, bedrock beneath ANL landfill site	610 feet MSL (almost 100 feet below soil surface).
General characteristics	Terrain - flat to slightly hilly. To the south, the floodplain of the Des Plaines River extends about 1/8 mile onto the forest preserve surrounding the site. The land rises sharply from the edge of the floodplain, and outcroppings of Niagara dolomite may be seen to the top of the bluffs overlooking the Des Plaines Valley. The Des Plaines River joins the Kankakee River about 30 miles southwest of the Laboratory to form the Illinois River.
ANL characteristics	The grounds of ANL contain a number of ponds and small streams, the principal one being Sawmill Creek. The site is drained primarily by Sawmill Creek, which runs through the site in a southerly direction and enters the Des Plaines River about 1.3 miles southeast of the center of the site.
ANL landfill site	There are no natural waterways on the landfill site, nor are there any known underground streams or mines at the site or within 1/4 mile of its boundary. A marshy area lies immediately to the west. Rainwater runs off after wetting the surface of the soil and there is little seepage of water into the ground at the landfill site. The earth cover placed on debris is predominantly clay, and it is estimated that less than 10% of the rainwater soaks into the landfill itself.
Soils	Above bedrock--dense, tough, silty clays. Few traces of sand. Soil borings indicate that there are no soft spots or layers of soft material. The soil is tough and hard in the area from the bottom of the building-foundation mats down to bedrock--about 100 feet.
Bedrock	Upper 10 feet of bedrock composed of large, fine-grained, gray dolomite of a slightly-weathered-to-sound condition. Preglacial erosion has worn off bedrock of more recent origin and has cut deeply into the dolomite top surface of the presently existing bedrock of the Des Plaines River Valley. Glacial till of the Wisconsin ice sheet deposited by the Valparaiso Moraine overlies this bedrock and partially fills the Des Plaines Valley.

shows monthly mean and extreme temperatures as recorded at Midway (NOAA 1980). These values are long-term averages and do not change appreciably in the matter of only a few years.

3.3.2 Winds

The average wind speed at Argonne at a height of 45 m (150 ft) is 5.5 m/s (12.3 mph); calm periods account for 2.0% of the time. At 5.8 m (19 ft) the average wind speed is 3.4 m/s (7.6 mph), with calm periods occurring 3.1% of the time.

Wind-speed and -direction data from Midway are illustrated in Table 3.4. The average wind speed at Midway is 4.65 m/s (10.4 mph). Calm periods occur 3.7% of the time. The predominant wind direction is south, accounting for 17% of the observations. Wind directions from the south through west sectors occur nearly 50% of the time.

Table 3.3. Monthly Mean and Extreme Temperatures at Midway Airport (°C)

	Normal (1941-1970)			Extreme (Year)	
Month	Max	Min	Mean	Max	Min
Jan	-0.3	-8.3	-4.3	19.4 (1950)	-28.3 (1977)
Feb	1.4	-6.6	-2.6	23.9 (1976)	-26.1 (1951)
Mar	7.0	-1.7	2.7	27.8 (1945)	-21.7 (1943)
Apr	15.2	4.7	9.9	31.1 (1977)	-8.9 (1975)
May	21.3	9.8	15.6	35.0 (1977)	-1.7 (1966)
Jun	27.0	15.7	21.4	40.0 (1953)	1.7 (1945)
Jul	29.1	18.3	23.7	39.4 (1956)	7.8 (1972)
Aug	28.5	17.8	23.2	38.3 (1947)	6.1 (1965)
Sep	24.3	13.3	18.8	38.3 (1947)	1.1 (1974)
Oct	18.4	7.6	13.0	34.4 (1963)	-6.7 (1948)
Nov	8.9	0.3	4.7	27.2 (1950)	-18.9 (1950)
Dec	1.8	-5.8	-1.9	21.7 (1970)	-25.6 (1960)

Table 3.4. Percent Joint Frequency Distribution of Average Wind Speed and Direction for Midway Airport, January 1965 - December 1974

Direction	Speed (m/s) 0-1.8	1.9-3.3	3.4-5.4	> 5.5	Total
N	0.3	1.1	2.2	2.5	6.1
NNE	0.1	0.5	1.1	1.7	3.4
NE	0.2	0.8	2.0	2.2	5.2
ENE	0.3	1.0	2.1	1.5	4.9
E	0.4	1.5	2.6	1.4	5.9
ESE	0.2	0.8	0.9	0.4	2.3
SE	0.3	1.2	1.7	1.0	4.2
SSE	0.2	0.8	1.5	1.1	3.6
S	0.9	3.5	6.0	6.4	16.8
SSW	0.5	2.0	3.3	3.0	8.8
SW	0.5	1.8	2.8	2.6	7.7
WSW	0.5	1.6	2.5	2.5	7.1
W	0.7	2.0	3.1	3.3	9.1
WNW	0.4	1.2	1.9	2.0	5.5
NW	0.4	1.3	2.1	2.1	5.9
NNW	0.2	0.7	1.3	1.3	3.5
Total	6.1	21.8	37.1	35.0	100.0

Meteorological data from Midway will be used as input to the air-pollution-dispersion models. Data from the ANL meteorological tower are not recorded in a format compatible with the EPA air-pollution models. The meteorological data from Midway are deemed adequate to describe the meteorological influences that control atmospheric dispersion in the vicinity of ANL.

3.3.3 Precipitation

Table 3.5 shows mean and extreme precipitation values at Midway Airport. The average annual precipitation at Midway Airport is 874 mm (34.4 in); the average

Table 3.5. Mean and Extreme Precipitation at Midway Airport, 1941-1970 (mm)

Month	Precipitation Mean	Max	Min	Snow Mean[a]
Jan	47	103	7	251
Feb	40	85	6	211
Mar	69	136	8	191
Apr	95	212	11	35
May	87	193	20	trace
Jun	100	225	20	0
Jul	103	228	34	0
Aug	80	246	20	0
Sep	76	359	12	0
Oct	67	306	5	7
Nov	56	128	14	74
Dec	53	169	8	274
Annual	874			1043

[a]Records from 1938-1978.

at ANL is 800 mm (31.5 in). Most of the precipitation falls in spring and summer and is associated with thunderstorm activity. Annual average accumulation of snow and sleet is 818 mm (32.2 in).

3.3.4 Storms

Snowstorms resulting in accumulations greater than 150 mm (6 in) occur only once or twice each year on the average (Denmark 1974). The greatest monthly snowfall was 1000 mm (40 in) in January 1979. The greatest 24-hour snowfall was 503 mm (19.8 in) in January 1967 (NOAA 1980). Severe ice storms occur only once every four or five years (Denmark 1974).

The area experiences about 40 thunderstorms annually (NOAA 1980). Occasionally, these storms are accompanied by hail, damaging winds, or tornadoes.

From 1957-1969 there were 371 tornadoes in the state, with more than 65% occurring in the spring months (NOAA 1970). The probability of a tornado strike at Argonne is 8.54×10^{-4} each year, or a recurrence interval of one tornado every 1200 years (USAEC 1974).

3.3.5 Air Quality

National and state ambient air-quality standards are listed in Table 3.6. Ambient air quality in the general vicinity of ANL is monitored at several sites. The Occupational Health and Safety Division of ANL monitors pollutants at five locations on the Laboratory property; the Illinois Environmental Protection Agency and Commonwealth Edison Company collect data from a number of sites around the Laboratory. Ambient air-quality monitoring-station locations are shown in Figure 3.5.

TSP and SO_2 data for sites operated by regulatory agencies, ANL, and Commonwealth Edison Company are listed in Tables 3.7 and 3.8, respectively. Monitors within a 16-km radius were selected to represent the local air quality.

Aside from ANL's monitor sites (8F, 12F, 12M, 14N, 18J), Darien and Lemont have the closest monitors. The highest particulate concentrations registered at these offsite monitors were 74 $\mu g/m^3$ for an annual geometric mean and 208 $\mu g/m^3$ for the second-highest 24-hour average, and are barely in compliance with primary air-quality standards. The appropriate national and state secondary ambient air-quality standards for TSP are 60 $\mu g/m^3$ measured on an annual basis, and 150 $\mu g/m^3$ measured on a 24-hour basis. The area does not comply with these figures; therefore, it is designated "nonattainment" for the secondary TSP air-quality standards.

The McCook and Romeoville TSP monitoring sites are about 12 to 14 km (7.5 to 8.5 mi) from ANL, in areas of high particulate generation. Monitoring data from McCook show an annual geometric mean of 110 $\mu g/m^3$, and 217 $\mu g/m^3$ as a second-highest 24-hour maximum; for Romeoville, the corresponding values are 66 $\mu g/m^3$ and 162 $\mu g/m^3$, respectively. The TSP level at the McCook monitor is in violation of the primary standard and is more than likely influenced by

Table 3.6. Summary of National and Illinois Ambient Air-Quality Standards[a]

Pollutant	Time of Average[b]	Primary Standard (at 25°C and 760 mm of Hg)	Secondary Standard
Particulate matter (TSP)	Annual geometric mean	75 $\mu g/m^3$	60 $\mu g/m^3$
	24 hours	260 $\mu g/m^3$	150 $\mu g/m^3$
Sulfur dioxide (SO_2)	Annual arithmetic mean	0.03 ppm (80 $\mu g/m^3$)	None
	24 hours	0.14 ppm (365 $\mu g/m^3$)	None
	3 hours	None	0.5 ppm (1300 $\mu g/m^3$)
Carbon monoxide (CO)	8 hours	9 ppm (10 mg/m^3)	Same as primary
	1 hour	35 ppm (40 mg/m^3)	Same as primary
Photochemical oxidants (O_3)	1 hour - state	0.08 ppm (160 $\mu g/m^3$)	Same as primary
	1 hour per day - federal	0.12 ppm (235 $\mu g/m^3$)	Same as primary
Non-Methane hydrocarbons (N-MHC)	3 hours (6 to 9 a.m.)	0.24 ppm (160 $\mu g/m^3$)	Same as primary
Nitrogen dioxide (NO_2)	Annual arithmetic mean	0.05 ppm (100 $\mu g/m^3$)	Same as primary
Lead (Pb)	Quarterly arithmetic mean	1.5 $\mu g/m^3$	Same as primary

[a]Illinois standards are identical to national standards with the exception of lead, for which no state standard exists.

[b]All standards with averaging time of 24 hours or less are not to be exceeded more than once per year.

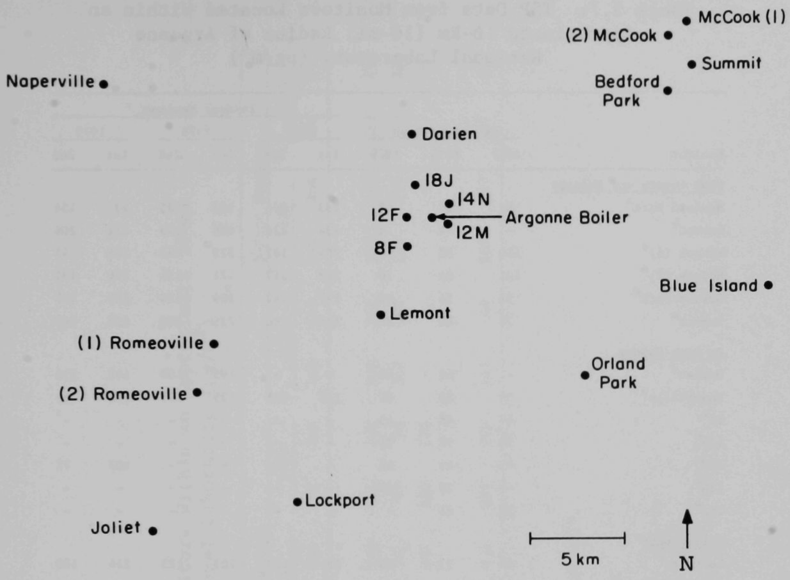

Figure 3.5. Monitoring-Station Locations Surrounding ANL.

Metropolitan Chicago/Cook County industry than by emissions from ANL. Evidence indicates that the TSP level near ANL is the result of fugitive emissions (Golchert et. al 1980).

On the basis of the monitoring results, the Illinois EPA has classified Downers Grove Township (the location of ANL) as nonattainment for secondary TSP standards. Adjacent Lemont Township in Cook County and Du Page Township in Will County are nonattainment for primary TSP standards (USEPA 1980).

The maximum measured annual-mean SO_2 concentration representative of the air quality at ANL is 45 $\mu g/m^3$, which was recorded at the Summit monitor. Monitoring of SO_2 on the laboratory site commenced in June 1980 in compliance with state regulations. However, the data are inconclusive because of the short time span they cover. The existing raw data indicate an average of 17 $\mu g/m^3$

Table 3.7. TSP Data from Monitors Located Within an Approximate 16-km (10-mi) Radius of Argonne National Laboratory (μg/m³)

	Geometric Mean			24-Hour Maximum					
				1977		1978		1979	
Monitor	1977	1978	1979	1st	2nd	1st	2nd	1st	2nd
Cook County and Chicago									
Bedford Park[a]	64	61	69	133	126	136	125	235	154
Lemont[b]	-[c]	74	d	134	126	489	195	211	208
McCook (1)[a]	110	87	74	209	187	212	145	148	147
McCook (2)[a]	101	81	70	219	217	171	151	140	131
Orland Park[a]	52	56	66	177	142	189	176	138	127
Summit[a]	78	80	84	196	186	225	209	194	193
Du Page County									
Darien[a]	-	69	69	-	-	195	188	143	135
Naperville[a]	58	53	60	165	135	135	131	122	119
8F[e]	47	48	45	-	-	-	-	-	-
12F[e]	58	58	55	-	-	-	-	-	-
12M[e]	43	48	45	-	-	-	-	107	71
14N[e]	-	38	43	-	-	-	-	-	-
18J[e]	52	61	-	-	-	-	-	-	-
Will County									
Lockport[a]	63	53	70	164	157	203	123	214	180
Romeoville (1)[b]	58	-	66	160	155	189	162	155	149
Romeoville (2)[a]	-	54	d	107	90	202	140	156	151

[a]Monitor operated by the Illinois Environmental Protection Agency.

[b]Monitor operated by Commonwealth Edison Company.

[c]Hyphen means no data.

[d]The value given for 1978 is an average for 1 January 1978 to 31 December 1979.

[e]Monitor on the ANL site.

and a maximum 24-hour concentration of 50 $\mu g/m^3$. There are no 3-hour observations. The Lemont monitor reported second-highest 24-hour and 3-hour values of 197 $\mu g/m^3$ and 416 $\mu g/m^3$, respectively, and an annual mean of 34 $\mu g/m^3$. These values are in compliance with air-quality standards.

The nearest NO_x monitor is located in Blue Island, about 20 km (13 mi) east-southeast. For the calendar years 1977 and 1978, the annual mean NO_x concentrations were 73 $\mu g/m^3$ and 100 $\mu g/m^3$, respectively. The latter figure is equal to the ambient air-quality standard. However, because ANL is located in a more rural area than Blue Island and because recently begun onsite NO_x monitoring data seem to indicate a lower ambient concentration (42 $\mu g/m^3$), the above data are not representative of the local air quality. A conservative assumption for the NO_x concentration in the vicinity of Argonne is 60 $\mu g/m^3$,

Table 3.8. SO_2 Data from Continuous Monitors Within an Approximate 16-km (10-mi) Radius of Argonne National Laboratory ($\mu g/m^3$)

	Arithmetic Mean			24-Hour Maximum						3-Hour Maximum					
				1977		1978		1979		1977		1978		1979	
Monitor	1977	1978	1979	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Cook County and Chicago															
Lemont[a]	-[b]	34	c	121	86	123	122	193	192	530	271	283	280	417	416
McCook[d]	37	29	26	152	152	139	131	97	95	362	307	289	268	223	218
Summit[d]	18	42	45	89	71	326	207	189	176	-	-	-	-	-	-
Will County															
Romeoville[a]	-	34	c	86	79	151	150	299	299	147	144	504	440	437	403

[a]Monitor operated by Commonwealth Edison Company.

[b]Hyphen means no data.

[c]The value given for 1978 is an average for 1 January 1978 to 31 December 1979.

[d]Monitor operated by the Illinois Environmental Protection Agency.

which is the ambient concentration measured in Joliet, 25 km (15 mi) southwest of the laboratory.

3.4 DEMOGRAPHY AND SOCIAL PROFILE

3.4.1 Demography of the Area and Vicinity

ANL occupies a part of Du Page County, Illinois, 40 km (25 mi) due west of Lake Michigan. It is about 35 km (22 mi) southwest of downtown Chicago and is within the Chicago Standard Metropolitan Statistical Area (SMSA).

The Chicago SMSA comprises six Illinois and two Indiana counties around the southwest corner of Lake Michigan. Its 1970 population was about 7.6 million (ANL 1979a). Cook County, which includes the City of Chicago, experienced an overall population decrease of 2.3% from 1970 to 1975 when it held an estimated 5,369,328 people. Chicago itself declined by 8% during that time, while the rest of the county grew by 7.9% (ANL 1979b).

The nearby areas of Will and Cook Counties have generally developed at a considerably lower rate than has the Du Page County area, except along the Illinois Waterway where industrial development has taken place. The estimated 1978 population by annular sector and radius within 80 km (50 mi) of the boiler is shown in Table 3.9. Included within the 80-km radius are portions of Lake and Porter Counties, Indiana; portions of Kankakee, Grundy, La Salle, De Kalb, McHenry, and Lake Counties in Illinois; and all of Du Page, Will, Cook, Kendall, and Kane Counties in Illinois (ANL 1979a).

Beyond the forest preserve at ANL's perimeter, the population density is low, except for a high-density residential area (with over 37 units per hectare and about 4500 residents) 600 m (2000 ft) east of the perimeter (ANL 1979a).

Du Page County's growth rate has been the highest of any metropolitan Illinois county, increasing from 155,000 to 596,000 between 1950 and 1976.

The onsite ANL population on 31 January 1980 was 5292 as shown in Table 3.10.

Table 3.9. 1978 Estimated Population Distribution

Direction from Site	Distance from Site (km)									
						Population in Thousands				
	0-1.6	1.6-3.2	3.2-4.8	4.8-6.4	6.4-8	8-16	16-32	32-48	48-64	64-80
N	0	226	2171	3516	4859	44.0	163	309	168	193
NNE	0	124	1932	4314	2837	77.5	420	449	99	0
NE	0	347	1445	1233	1422	45.7	505	626	0	0
ENE	0	1729	3069	470	1617	45.0	684	289	0	0
E	0	9	212	0	12	19.2	653	508	13	26
ESE	0	0	88	275	118	18.6	213	320	308	46
SE	0	3	132	174	62	13.0	82	96	23	9
SSE	0	29	452	434	115	6.1	23	11	14	19
S	0	65	1305	688	772	3.9	31	4	27	40
SSW	0	39	3741	4557	665	11.8	97	8	18	7
SW	0	408	157	88	84	15.5	32	8	16	8
WSW	0	323	46	1199	2193	17.8	14	10	6	10
W	0	1242	740	7910	8852	13.4	42	18	15	8
WNW	0	662	136	2556	3960	24.5	73	46	6	52
NW	0	141	674	2267	6090	28.5	68	78	13	13
NNW	0	212	1390	1470	3414	37.0	101	135	91	66
Total		5559	17692	31151	37077	421.0	3202	2915	815	497
Cumulative		5559	23251	54402	91479	512.0	3714	6629	7444	7941

Table 3.10. ANL Population as of 31 January 1980

Type of Personnel	Number
Engineers/scientists	1686
Management/administrative	579
Technical/nonsupervisory	15
Administrative	127
Supervisory	136
Technical	486
Clerical	600
Other	744
Temporary ANL personnel (paid)	169
Temporary ANL personnel (unpaid)	449
DOE personnel	301
Total	5292

3.4.2 Socioeconomic Profile

ANL is a multiprogram laboratory with research, development, and demonstration in five major scientific and technical areas: physical research, high-energy physics, biomedical and environmental research, energy and environment, and engineering research and development. These programs require many service and support personnel.

With its work force of about 5000 people, ANL is one of the three largest employers in Du Page County. In 1975 only 16 organizations in the county had 1000 or more employees; statewide, 24 organizations had work forces of over 5000 (US Dep Comm 1977). Employees commute over distances greater than 50 km (30 mi); thus the payroll is spread widely. However, nearby villages do house high numbers of ANL employees, notably Lemont (in 1977, 211 of a 5200 population) and Downers Grove (482 of a 43,800 population). The laboratory also purchases much of its utilities, outside services, equipment, and supplies locally (ANL 1979a).

In the past several years industrial parks have been constructed to the north and northwest of the laboratory. In addition to the large number of residences in the area, many commercial enterprises have been established (ANL 1979a).

The Chicago metropolitan area as a whole is well traversed by major transportation corridors. ANL is located in an area served by Interstate 55 and State Highways 83 and 171. It is also proximate to rail lines and waterways including the Des Plaines River and the Chicago Sanitary and Ship Canal.

3.5 LAND RESOURCES

ANL occupies a 690-ha (1700-acre) tract in the Des Plaines River Valley, south of Interstate 55 and west of Illinois Highway 83. On the perimeter of the site is an 826-ha (2040-acre) forest preserve. Beyond the preserve is mostly low-density residential area, except for one high-density area 600 m (2000 ft) east of the perimeter (ANL 1979a).

Du Page County's developed-land area increased between 1950 and 1976 from 30,400 to 51,400 ha (75,100 to 127,000 acres). In 1976 the land-use categories occupied the following percentages of land (ANL 1979a):

Residential	40%
Commercial	3.8
Office, R&D	6.3 (ANL category)
Manufacturing	3.1
Transportation	23
Open space	19

The Laboratory and support facilities occupy about 80 ha (200 acres), with the remaining 610 ha (1500 acres) devoted to forest and landscape areas within the site perimeter. Figure 3.6 illustrates the internal site plan (ANL 1979a).

Large oil refineries are located about 8 and 11 km (5 and 7 mi) southwest of ANL along the Illinois Waterway, and a large coal-burning electrical generating station is also about 11 km (7 mi) to the southwest. In addition, several large pipeline terminals have been built for bulk storage of petroleum products and other chemicals. Finally, a sizable wildlife preserve has been set aside along the Des Plaines River about 1.6 km (1 mi) to the southeast of ANL (ANL 1979a).

ANL is located on federally owned land and is subject to federal rules governing water and air quality, and to federal and state environmental-protection laws. The Laboratory was established in Du Page County before any comprehensive land use plans were available. Nevertheless, the continued operation of ANL is consistent with the present land-use plans of Du Page and neighboring Cook and Will Counties. The purposes of the land-use plans of the six northeastern Illinois counties are to provide a balance of land uses and to provide a maximum of economic, recreational, and esthetic benefits from the use of the land (ANL 1979a).

The land-use plans for Du Page County largely correspond to present uses, i.e. mostly low-density residential with smaller fractions of other uses. About 80% of the county land is expected to be developed by the year 2000.

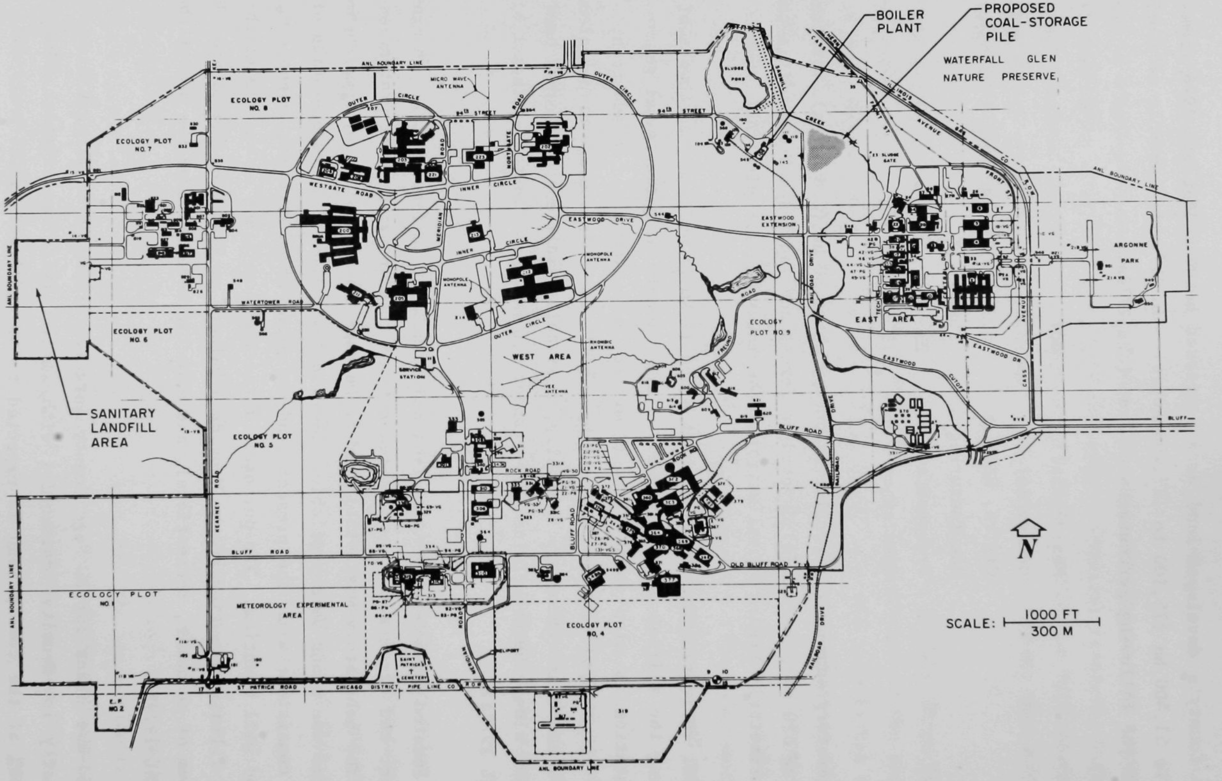

Figure 3.6. ANL Site Plan Showing Locations of Sanitary Landfill, Boiler Plant, and Proposed Coal-Storage Pile.

The largest relative increase is in the moderate-density residential category, projected to go from 1.4% to 3.3% of the developed area. Du Page County is considered to be a highly desirable area for the "office, research and development" category, which includes ANL, and the plan calls for a doubling of this area. An important concern of the plan is the establishment of open spaces, for recreation as well as for buffers and green space to serve as linkages between urbanized communities. Sensitive natural-resource areas such as floodplains and water-recharge areas, which in part constitute the ANL-Waterfall Glen area, are protected by the open-space limitations (ANL 1979a).

3.6 HISTORICAL AND ARCHEOLOGICAL RESOURCES

During 1978 and 1979, a cultural-resource survey was conducted on portions of the ANL site designated as undisturbed by the construction of current facilities. Within this area, a site-identification program was devised consisting of shovel tests made along transects of varying widths. This program was completed over about 60% of the site, as shown in Figure 3.7. As a result of this study, 18 prehistoric and 3 historic sites were identified. Historic sites were found to date from the late-19th/early-20th centuries and are believed to represent early homesteads. Prehistoric sites date primarily from the late mid-Archaic periods (4000-1000 B.C.), although an early Late Woodland component (A.D. 700-1200) has been identified at one site. These prehistoric sites appear to have functioned as temporary base camps/hunting stations, reflecting what may prove to have been a unique adaptation to local environments. Preliminary studies indicate that areas with the highest potential for cultural resources are those near watercourses and on knolls overlooking swampy depressions. This hypothesis may be refined when the remainder of the site is surveyed.

In 1980, a survey was initiated for the area surrounding the ANL steam generating plant and associated creek terrace. These areas were not inspected during the previous field seasons. Based on shovel testing and stratigraphic information from deep trenches cut across the terrace, it was determined that this area was composed of fill. If prehistoric or historic sites remain in this area, they are expected to be deeply buried by the fill and would not be affected by current construction activities.

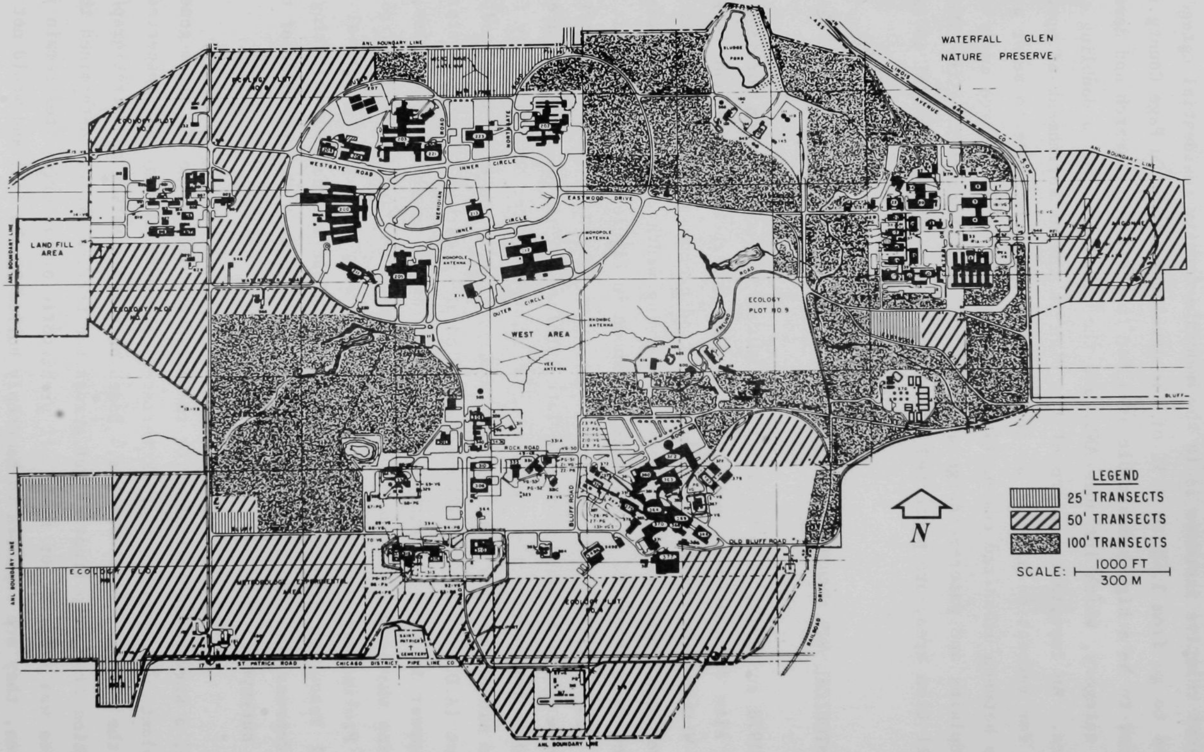

Figure 3.7. Areas Surveyed in 1978 and 1979 by Shovel Testing.

3.7 WATER RESOURCES

3.7.1 Surface Water

The nearest natural surface-water body to the boiler plant and the major surface-drainage sink for the ANL site is Sawmill Creek. The creek originates about 2.5 km (1.5 mi) north of the ANL site, enters the site 269 m (884 ft) north of the boiler building, flows through the site in a southerly direction, and leaves near the southeast corner. The ANL sewage discharge enters the creek about 1 km (0.6 mi) south of the fence (outside the ANL site) and the creek joins the Des Plaines River about 0.6 km (0.4 mi) beyond the sewage discharge. A few small tributary streams drain much of the site and several ponds have been formed by dams on the streams.

The average annual flow of Sawmill Creek is about 0.3 m^3/s (11 cfs) with extremes of 0.10 m^3/s and 27.9 m^3/s (3.6 and 984 cfs). About 0.13 m^3/s (4.6 cfs) of the flow is discharged from the Marion Brook (Du Page County) sewage-treatment plant upstream of ANL. The creek is moderately high in sewage-generated contaminants such as BOD, nutrients, and trace elements and is moderately polluted. The stream is classified as water-quality limited with respect to the dissolved-oxygen level. Water-quality analyses for the creek below the ANL site and the ANL sewer outlet, showing the ANL contributions, are given in Tables 3.11 and 3.12. State instream standards are shown in Table 3.13. No recreational or industrial use is made of the creek, although it does provide scenic values as it flows through the forest preserve below ANL.

At present, ANL does not regularly monitor Sawmill Creek (other than for bacteria) at the inflow to the ANL site; however, chemical monitoring may be required by the Illinois EPA before beginning construction of the new coal-storage area.

Of the samples in Table 3.12 that have violated state instream standards for chromium, copper, iron, mercury, and silver, chromium and iron are the result of upstream turbidity and contamination. ANL is believed to contribute a small part (about 5 μg/L) of copper, although the high levels are not fully

Table 3.11. Effect of Sanitary Waste in Sawmill Creek[a]

Parameter	Location[b]	No. of Samples	Value: Avg	Value: Min	Value: Max	Percentage of Standard	Percentage of Samples Exceeding State Standard
Ammonia	7M (up)	39	2.3 ± 0.7	0.1	9.4	153	59
nitrogen (mg/L)	7M (down)	39	1.8 ± 0.5	0.1	6.6	120	49
Dissolved	7M (up)	45	108 ± 7	47	155	-	-
oxygen[c]	7M (down)	45	110 ± 5	69	143	-	-
Temperature	7M (up)	45	15.8 ± 1.9	4.7	26.6	-	-
(°C)	7M (down)	45	16.7 ± 1.7	6.2	26.3	-	-
Total dissolved	7M (up)	45	1184 ± 136	446	2085	118	58
solids (mg/L)	7M (down)	45	954 ± 85	458	1617	95	53

[a]From "Environmental Monitoring at Argonne National Laboratory," Annual Report for 1979, ANL-80-29.

[b]Location 7M (up) is 15 m (50 ft) upstream from the wastewater outfall. Location 7M (down) is 60 m (200 ft) downstream from the outfall.

[c]Percentage saturation at measured temperature.

Table 3.12. Chemical Constituents in Sawmill Creek at Location 7M (down)[a,b]

Constituent	No. of Samples	Concentration (μg/L except pH) Avg	Min	Max	Percentage of Standard (avg)	Percentage of Samples Exceeding State Standard
Arsenic	52	< 10	–	< 10	< 1	0
Barium	52	52 ± 7	16	132	1	0
Beryllium	10	0.094 ± 0.047	< 0.04	0.270	–	–
Cadmium	52	1.3 ± 0.2	< 0.4	2.7	2.6	0
Chromium (VI)	52	< 10	< 10	240	< 20	2
Chromium (III)	52	24 ± 9	6	154	2.4	0
Copper	52	36 ± 8	6	161	180	54
Cyanide	45	< 20	–	< 20	< 80	0
Fluoride	52	340 ± 30	200	800	24	0
Iron	52	1310 ± 510	180	1040	131	31
Lead	52	13.6 ± 4.6	< 2	86	13.6	0
Manganese	52	159 ± 40	30	880	14.5	0
Mercury	236	0.22 ± 0.04	< 0.1	4.3	44	8
Nickel	52	9.9 ± 2.3	< 3	42.2	1	0
pH	236	–	7.2	8.3	–	0
Selenium	46	< 10	–	< 10	< 10	0
Silver	52	2.1 ± 0.3	0.4	5.8	42	2
Zinc	52	120 ± 30	40	570	12	0

[a]Location 7M (down) is 60 m (200 ft) downstream from the wastewater outfall.

[b]From "Environmental Monitoring at Argonne National Laboratory," Annual Report for 1979, ANL-80-29.

understood. The mercury and silver violations probably result from ANL operation.

The Des Plaines River is the major drainage sink for the region. The flow ranges from 12 to 340 m^3/s (420 to 12,000 cfs) with a generally poor water quality. The volume of flow and quality of water are such that neither Sawmill Creek nor ANL operations have any detectable effect on the river.

3.7.2 Groundwater

There are two principal aquifers used as water supplies in the ANL area. The upper aquifer is the Niagara-Alexandrian dolomite with the piezometric surface now between 15 m (50 ft) and 30 m (100 ft) below the ground surface over much of the site. The lower aquifer is the Galesville sandstone, a part of the

Table 3.13. Illinois Water-Pollution Regulations - General Standards for State Waters[a]

Constituent	Storet Number	Concentration (mg/L)
Ammonia nitrogen (as N)	00610	1.5
Arsenic (total)	01002	1.0
Barium (total)	01007	5.0
Boron (total)	01022	1.0
Cadmium (total)	01027	0.05
Chloride	00940	500
Chromium (total hexavalent)	01032	0.05
Chromium (total trivalent)	01033	1.0
Copper (total)	01042	0.02
Cyanide	00720	0.025
Fluoride	00951	1.4
Iron (total)	01045	1.0
Lead (total)	01051	0.1
Manganese (total)	01055	1.0
Mercury (total)	71900	0.0005
Nickel (total)	01067	1.0
Phenols	32730	0.1
Selenium (total)	01147	1.0
Silver (total)	01077	0.005
Sulfate	00945	500
Total dissolved solids	70300	1000
Zinc	01092	1.0

[a]From Illinois Pollution Control Board Rules and Regulations, Chapter 3, "Water Pollution" (includes 24 May 1979 amendments).

Cambrian-Ordivician aquifer, which lies between 150 m and 450 m (500 and 1500 ft) below the surface.

The four ANL wells now in use are 90 m (300 ft) deep in the Niagara dolomite and have yields of 1300 to 1900 L/min (350 to 500 gpm). Water-quality data for the wells are shown in Table 3.14. One unused well is in the Galesville sandstone and is 490 m (1600 ft) deep. However, the water table has dropped below the pumping level and the well is no longer usable. The water level in the Niagara dolomite has remained reasonably stable under ANL pumping of about 3800 m^3/d (1 million gpd), dropping 1.5 m (5 ft) between 1960 and 1970. At present, the aquifer appears adequate for future plant use; however, recent heavy suburban development in the site area may cause substantial declines in the water level.

The Galesville sandstone aquifer, although very productive, has been subject to very severe withdrawals in the Chicago area, and the level has dropped 150 m (500 ft) since 1864, and 30 m (100 ft) since 1949. As a consequence of the drawdown, severe water shortages have occurred for many villages using this aquifer.

Although the Niagara aquifer is recharged by percolation from the surface, the penetration is very slow through the dense surface clays. Any surface contamination near the steam plant is likely to run off or diffuse in a shallow layer to the Sawmill Creek drainage.

3.8 SOILS

The distribution of soil types across the ANL site are illustrated in Figure 3.8; characteristics of the major soil types are presented in Table 3.15. The most commonly occurring soils on the ANL site are of the Morley series, which are moderately well-drained, silt loam soils with a relatively low organic-matter content (US Dep Agric 1970, ANL 1979a, Curtis and Berlin 1980). The soils underlying the ANL boiler plant and the proposed coal-storage pile are of the Sawmill series. These dark brown to black soils are silty clay loams, formed in alluvium on floodplains. Sawmill soils are generally poorly

Table 3.14. Water-Quality Data for ANL Wells and Domestic Water (mg/L except pH)[a]

Constituent	Well Number 1	2	3	4	Treated Domestic Water
Alkalinity (as $CaCO_3$)	360	340	336	336	64
Calcium	104	101	112	101	22
Chloride	42	20	24	16	30
Fluoride	--------------not measured-------------				0.8
Hardness (as $CaCO_3$)	500	480	516	488	74
Iron	1.39	0.08	1.06	0.94	< 0.01
Magnesium	60	56	57	57	4
Nitrate	< 1	< 1	< 1	< 1	< 1
pH	7.4	7.2	7.2	7.1	10.5
Phosphate	0.9	0.1	0.1	0.2	0.8
Potassium	4	4	4	4	3
Residue upon evaporation	640	594	630	582	440
Silica	15.1	14.1	13.5	16.1	10.9
Sodium	29	26	22	22	114
Sulfate	121	137	157	136	208

[a]From ANL (1979a).

drained and have a high water-holding capacity (US Dep Agric 1970, ANL 1979a, Curtis and Berlin 1980). The soils in the area of the boiler plant have been considerably disturbed by construction activities and vehicular traffic.

At the ANL sanitary landfill (see Fig. 3.8 and Table 3.15), the deposited waste material presumably covers Beecher, Markham, and/or Peotone soils. The soils in unfilled sections of the landfill are Peotone silty clay loams and Beecher silt loams. These soils are slowly permeable and poorly drained. Markham silt loam soils occur on steeper slopes and are better drained than the Peotone and Beecher soils. Much of the landfill site has been compacted by heavy vehicular traffic.

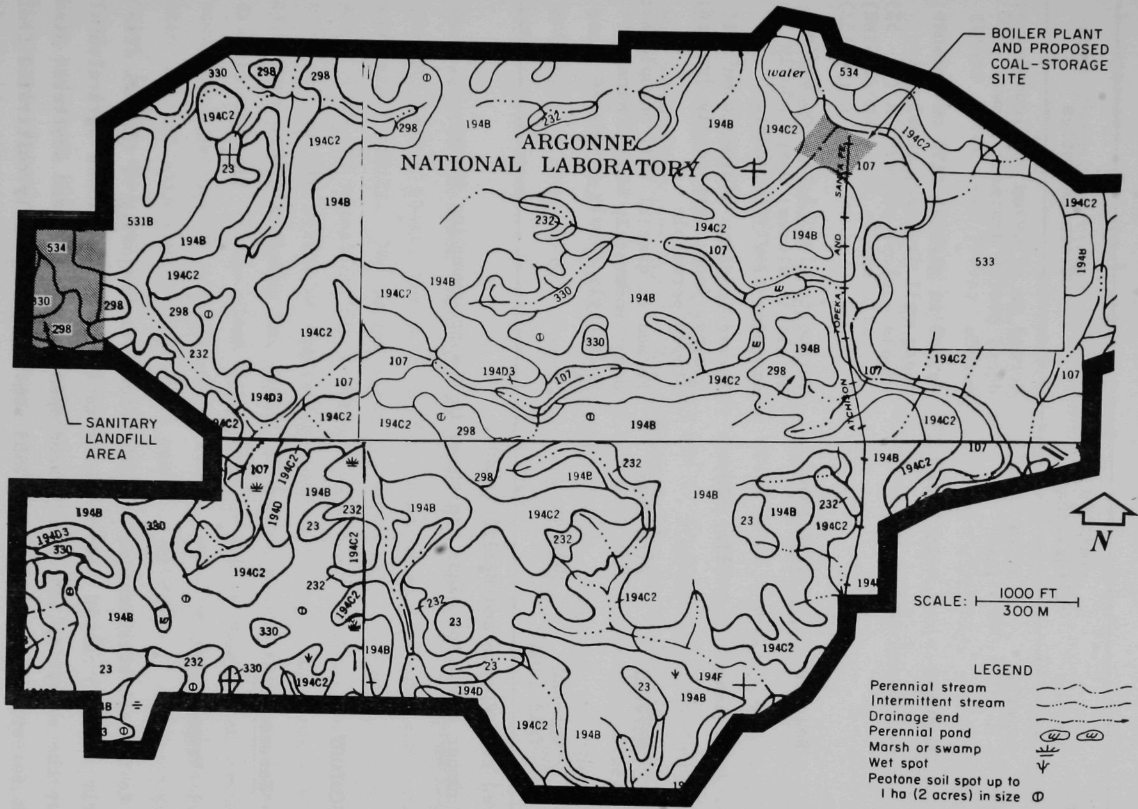

Figure 3.8. Soil Types of the ANL Site. (Letters indicate slope class--see accompanying table--and numbers following class indicate whether soils are [2] eroded or [3] severely eroded.)

Table 3.15. Soil Types of the ANL Boiler-Plant Vicinity and Sanitary-Landfill Area[a]

Number[b]	Series	Texture Classification	Characteristics
107	Sawmill	Silty clay loam	Formed in alluvium on floodplains; deep; poorly drained; slowly permeable
194	Morley	Silt loam	Formed in glacial till on uplands; deep; well drained; slowly permeable - slope class:[b] A (2%- 5%) B (5%-10%) C (7%-15%)
298	Beecher	Silt loam	Formed in glacial till on plains or slight slopes; deep; poorly drained; slowly permeable
330	Peotone	Silty clay	Formed in silty sediments on till plains; deep; very poorly drained; slowly permeable
531	Markham	Silt loam	Formed in glacial till on uplands; deep; moderately well drained; moderately slowly permeable
533,534	Cut-and-fill land	Clayey	

[a]Adapted from Curtis and Berlin (1980).

[b]Soil number and slope class are shown in the accompanying figure.

3.9 ECOLOGY

3.9.1 Terrestrial

3.9.1.1 Vegetation

Prior to the establishment of the Laboratory, the majority of the ANL site was actively farmed. About 75% of the site consisted of plowed agricultural fields; the remaining 25% were grazed open oak woodlots and scattered stands of oak forest. Between 1953 and 1955 some of the formerly cultivated fields of the site and the peripheral forest preserves were planted with jack, white, and red pine (Pinus banksiana, P. strobus, and P. resinosa) (ANL 1979a). The remaining open fields of the site, not committed to laboratory development, are in various stages of old-field succession and are usually dominated by bluegrasses (Poa spp.) and various forbs, but dense invasive growths of crown vetch (Coronilla varia) have become established in some areas (Messenger et al. 1969). The crown vetch was initially planted along road rights-of-way and in certain fields to help control soil erosion and provide low-maintenance ground cover (ANL 1979a). These old-field communities also contain widely spaced shrubs including hawthorns (Crategus spp.), cherries (Prunus spp.), and blackberry (Rubus sp.). Several large cattail (Typha latifolia) marshes occur on the west side of the site.

The deciduous forest stands of the site are dominated by various species of oak: bur oak (Quercus macrocarpa), white oak (Q. alba), red oak (Q. rubra), and black oak (Q. velutina). Tree species variously interspersed with the oaks include hickories (Carya ovata and C. cordiformis), hawthorns, cherries, and ashes (Fraxinus spp.). The overstory of some stands consists of old, large, widely spaced trees with low branches indicative of maturation in open areas rather than in dense forest (ANL 1979a). Saplings and shrubs occur primarily in open areas. A more detailed description of the flora of the ANL site is presented by Messenger et al. (1969).

The areas of the site that will be directly impacted by the proposed action are the boiler plant, the site of the proposed coal-storage pile, and the sanitary landfill. The boiler plant and associated structures are situated on about 4 ha (10 acres) in the northeast corner of the site, as shown in Figure 3.6. As the result of continuing construction and maintenance activities that have occurred during the operation of the plant, the open areas immediately adjacent to the plant are nearly devoid of vegetation, except for occasional patches of grasses and/or forbs. Most of these open areas have been covered with crushed limestone gravel. Several old-field communities exist to the east and west of the boiler plant. A remnant of an old asphalt road is about 100 m (300 ft) southeast of the site of the proposed coal-storage pile and about 300 m (1000 ft) east-southeast of the boiler plant (see Fig. 3.2). The proposed coal-storage pile would displace about 1.3 ha (3.2 acres) of the old-field community to the east of the boiler plant. In 1967, a quantitative survey of an old-field community considered to be typical of those found on the ANL site was conducted (Messenger et al. 1969); plant species observed during this survey are presented in Table 3.16. Grasses constituted about 85% of the plant cover in the survey area; the remainder consisted of composites, crucifers, and legumes. Widely spaced individuals of hawthorn, cherry, and blackberry were also noted (Messenger et al. 1969). Stands of conifers and some deciduous trees occur to the northeast (across Sawmill Creek) of the boiler plant. A large stand of deciduous trees occurs to the south and southwest of the plant.

About 75% of the sanitary-landfill area (shown in Fig. 3.6) is actively in use, i.e. is continuously disrupted by the deposition of waste materials and cut-and-fill operations, thus precluding the establishment of vegetation. The remaining 25% (the northeast corner) has been filled to the maximum grade. The filled area has been dressed with topsoil, and grass and a few trees have recently been planted.

3.9.1.2 Wildlife

The ANL site serves as an effective refuge for many species of animals. The plant communities present on the site provide a wide variety of habitat types. The mammals, birds, and herpetofauna commonly observed or likely to occur on the site are listed in Tables 3.17, 3.18, and 3.19, respectively. These animals characteristically inhabit open fields, forest and forest-edge, and/or wetland communities of the Midwest. A more detailed description of the fauna of the ANL site can be found in Messenger et al. (1969). In addition to the birds listed in Table 3.19, other species occasionally use the ANL site and its environs as a stopover during spring and fall migrations (ANL 1979a).

The most visible mammals on the ANL site are the white variety of fallow deer (*Dama dama*). This exotic, southern European species was introduced prior to the 1947 acquisition of the site by the federal government. Because of the currently high fallow-deer population ($\sim$ 400-500 individuals), there are now several territorial herds existing in the wooded areas within the perimeter fence. A few individuals occasionally forage outside the fence in the neighboring forest preserves (ANL 1979a).

Table 3.16. Species Composition of a Typical Old-Field Community at the ANL Site[a]

Common Name	Scientific Name
Grasses	
Bluegrasses	Poa spp.
Timothy	Phleum sp.
Foxtail	Alopecurus sp.
Forbs	
Aster	Aster sp.
Avens	Geum sp.
Bindweed	Convolvulus sp.
Cinquefoil	Potentilla sp.
Cocklebur	Agrimonia sp.
Common dandelion	Taraxacum offcinale
Common milkweed	Asclepias syriaca
Common strawberry	Fragaria virginiana
Common thistle	Cirsium sp.
Crown vetch	Coronilla varia
Daisy fleabane	Erigeron annuus
Goldenrod	Solidago sp.
Grape	Vitis sp.
Horse-nettle	Solanum carolinense
Prairie-dock	Silphium terebinthinaceum
Queen Anne's lace	Daucus carota
Ragweeds (undifferentiated)	Ambrosia spp.
Sow-thistle	Sonchus sp.
Sweet clover	Melilotus sp.
Violets (undifferentiated)	Viola spp.
Winter-cress	Barbarea spp.
Wood-sorrel	Oxalis sp.
Yarrow	Achillea millefolium

[a]Adapted from Messenger et al. (1969).

Table 3.17. Mammals Commonly Observed or Likely to Occur on the ANL Site[a]

Common Name	Scientific Name
Beaver	Castor canadensis
Deer mouse	Peromyscus maniculatus
Eastern chipmunk	Tamias striatus
Eastern cottontail	Sylvilagus floridanus
Eastern gray squirrel	Sciurus carolinensis
Eastern mole	Scalopus aquaticus
European fallow deer	Dama dama
Gray fox	Urocyon cinereoargenteus
House mouse	Mus musculus
Little brown myotis	Myotis lucifugus
Longtail weasel	Mustela frenata
Meadow jumping mouse	Zapus hudsonius
Meadow vole	Microtus pennsylvanicus
Muskrat	Ondatra zibethica
Norway rat	Rattus norvegicus
Opossum	Didelphis marsupialis
Prairie vole	Microtus ochrogaster
Raccoon	Procyon lotor
Red fox	Vulpes fulva
Shorttail shrew	Blarina brevicauda
Striped skunk	Mephitis mephitis
Thirteen-lined ground squirrel	Citellus tridecemlineatus
White-footed mouse	Peromyscus leucopus
Whitetail deer	Odocoileus virginianus
Woodchuck	Marmota monax

[a]Adapted from ANL (1979a).

Table 3.18. Birds Commonly Observed or Likely to Occur on the ANL Site[a]

Summer Residents		Winter Residents	
Common Name	Scientific Name	Common Name	Scientific Name
American goldfinch	Spinus tristis tristis	American goldfinch	Spinus tristis tristis
Barn swallow	Hirundo rustica erythrogaster	Black-capped chickadee[b]	Parus atricapillus
Belted kingfisher	Megaceryle alcyon alcyon	Blue jay[b]	Cyanocitta cristata
Black-capped chickadee[b]	Parus atricapillus	Cardinal	Richmondena cardinalis
Blue jay[b]	Cyanocitta cristata	Common crow[b]	Corvus brachyrhynchos
Brown-headed cowbird	Molothrus ater ater	Common grackle	Quiscalus quiscula
Brown thrasher	Toxostoma rufum rufum	Downy woodpecker	Dendrocopos pubescens
Cardinal	Richmondena cardinalis	Hairy woodpecker	Dendrocopos villosus
Catbird	Dumetella carolinensis	Horned lark	Eremophila alpestris
Chimney swift	Chaetura pelagica	House sparrow[b]	Passer domesticus domesticus
Chipping sparrow[b]	Spizella passerina passerina	Mallard[b]	Anas platyrhynchos platyrhynchos
Common crow[b]	Corvus brachyrhynchos	Red-bellied woodpecker	Centurus carolinus
Common flicker	Colaptes auratus	Red-headed woodpecker	Melanerpes erythrocephalus erythrocephalus
Common grackle[b]	Quiscalus quiscula	Red-tailed hawk	Buteo jamaicensis
Common nighthawk	Chordeiles minor	Rock dove	Columba livia
Common oriole	Icterus galbula	Song sparrow[b]	Melospiza melodia
Downy woodpecker	Dendrocopos pubescens	Starling[b]	Sturnus vulgaris vulgaris
Eastern kingbird	Tyrannus tyrannus	Tree sparrow[b]	Spizella arborea arborea
Field sparrow[b]	Spizella pusilla pusilla		
Hairy woodpecker	Dendrocopos villosus		
Horned lark	Eremophila alpestris		
House sparrow[b]	Passer domesticus domesticus		
Indigo bunting	Passerina cyanea		
Killdeer	Charadrius vociferus vociferus		
Mallard[b]	Anas platyrhynchos platyrhynchos		
Mourning dove	Zenaidura macroura		
Purple martin	Progne subis subis		
Red-bellied woodpecker	Centurus carolinus		
Red-headed woodpecker	Melanerpes erythrocephalus erythrocephalus		
Red-tailed hawk	Buteo jamaicensis		
Red-winged blackbird[b]	Agelaius phoeniceus		
Ring-necked pheasant	Phasianus colchicus torquatus		
Robin[b]	Turdus migratorius		
Rock dove	Columba livia		
Rose-breasted grosbeak	Pheucticus ludovicianus		
Rough-winged swallow	Stelgidopteryx ruficollis serripennis		
Rufous-sided towhee	Pipilo erythrophthalmus		
Song sparrow	Melospiza melodia		
Sparrow hawk	Falco sparverius		
Starling[b]	Sturnus vulgaris vulgaris		
Tree swallow	Iridoprocne bicolor		
Western meadowlark	Sturnella neglecta		
Yellow-throated warbler	Dendroica dominica		

[a]Adapted from ANL (1979a).

[b]More abundantly occurring species.

Table 3.19. Reptiles and Amphibians Commonly Observed or Likely to Occur on the ANL Site[a]

Common Name	Scientific Name
Reptiles	
Brown snake	Storeria dekayi
Common garter snake	Thamnophis sirtalis
Eastern box turtle	Terrapene carolina carolina
Eastern mud turtle	Kinosternon subrubrum
Fox snake	Elaphe vupina
Gopher tortoise	Gopherus polyphemus
Northern water snake	Nerodia sipedon
Amphibians	
Bullfrog	Rana catesbeiana
Northern leopard frog	Rana pipiens
Spring peeper	Hyla crucifer
Striped chorus frog	Pseudacris triseriata
Tiger salamander	Ambystoma tigrinum

[a]Adapted from ANL (1979a) and Messenger et al. (1969).

The ANL boiler plant and associated structures are not suitable habitats for most animals; however, rock doves (Columba livia) regularly roost in the loft tower of the boiler plant. Other birds are commonly sighted in the boiler-plant area, but do not appear to nest in the immediate vicinity. Snakes have been observed sunning themselves in the open gravel-covered areas that surround the boiler plant. The more mobile mammals regularly traverse the boiler-plant site while moving between the plant communities bordering the area (see Sec. 3.9.1.1). The proposed site of the coal-storage pile is presently an old-field plant community providing habitat for small rodents, birds, and other animals, as well as providing forage for the fallow deer. Evidence of beaver (Castor canadensis) activity has been found on the banks of Sawmill Creek.

The actively used section of the sanitary landfill is unsuitable habitat for most wildlife species, with the exception of resident mice and other small rodents. However, a number of species including raccoons, weasels, opossums, woodchucks, reptiles, and amphibians commonly forage among the waste material deposited in the area. The landfill is also frequented by ring-necked pheasants, red-winged blackbirds, common grackles, and other birds from nearby cattail marshes. It has not been determined whether wildlife will become reestablished on the recently revegetated portion of the landfill.

3.9.1.3 Endangered and Threatened Species

A consultation with the U.S. Fish and Wildlife Service concerning the occurrence of endangered or threatened species within the vicinity of the ANL site indicates that the only species that may be present is the endangered Indiana bat (Myotis sodalis) (Bumgarner 1980). Indiana bats breed throughout Illinois, frequenting floodplains and riparian habitats. Females and juveniles are more commonly seen in riparian areas during the summer months, roosting under the bark of dead or dying trees. Males use floodplain ridges and hillside forests to forage, but usually roost in caves. Ecological surveys have not identified this species on the ANL site (ANL 1979a). Inasmuch as the area that will be occupied by the coal-storage facility does not provide suitable habitat for the Indiana bat, it is unlikely that the proposed action will have an adverse affect on this endangered species.

3.9.2 Aquatic

The aquatic resources of the ANL site are diverse. In addition to streams and man-made impoundments, the site also has a network of ditches to transport runoff. Inasmuch as the ditches support little aquatic biota other than macrophytes, primarily cattails, they are not addressed here.

The major portion of the site is drained by Freund Brook, which is formed by two intermittent branches. The gradient of the stream is relatively steep, and riffle habitat predominates. The substrate is coarse rock and gravel on a firm mud base. Primary production in the stream is limited by shading, but diatoms and some filamentous algae are common. Invertebrate fauna consist primarily of dipteran larvae, crayfish, caddisfly larvae, and midge larvae. Few fish are present due to the low summer flows and high temperatures. Freund Brook is impounded three times within less than a kilometer upstream from its confluence with Sawmill Creek. The three impoundments follow one after the other and progressively increase in size and depth and diversity of aquatic biota. The upstream pond is small, shallow, and almost silted in. Fish are rare, but macrophytes such as giant bulrush, water plantain, and other rushes are present. The middle impoundment is primarily open water with a small littoral zone. Waterfowl (i.e. ducks and swans) use this pond, and other than an occasional "bloom" of duckweed, macrophytes are rare. Primary producers are algae. Cyclotella, a centric diatom, constitutes about 50% of the algal community, which has low diversity but greater biomass than in the other two impoundments, probably due to the nutrient inputs from the resident waterfowl. The pond has not been sampled, but sunfishes and minnows have been observed. The lower impoundment has a small littoral zone inhabited by cattails, rushes, and other macrophytes. Observations have shown the fish community to be dominated by sunfish, with a few species of minnows also present.

The two major aquatic resources near Boiler No. 5 are a 2.8-ha (7-acre) sludge pond, which receives primarily water-softening wastes (lime) from the site water-treatment plant, and Sawmill Creek, which flows east of the plant from north to south.

The sludge pond is quite shallow in most places, only a few centimeters above the settled carbonate-rich sludge. The high pH of the water excludes most biota; however, some phytoplankton do occur, primarily bluegreen algae, pennate diatoms, and flagellates. Solid substrates are occasionally covered by mats of bluegreen algae, and the pond is encircled by a narrow band of cattails. A few aquatic reptiles and amphibians have been observed in the pond, and it has been intermittently used by waterfowl. No waterfowl have been reported using a nearby small lime pond of less than 0.15 ha (0.4 acre).

The biota of Sawmill Creek reflect its high silt load, steep gradient, and sewage effluent from the Marion Brook (Du Page County) sewage-treatment plant upstream of ANL. Primary production is high due to nutrients supplied from sewage effluent and organic matter from watershed drainage. Dense periphytic algal growth occurs on much of the rocky substrate. Periphyton are dominated by filamentous green algae with a diverse assemblage of diatoms. Phytoplankton are primarily green algae and diatoms. The macroinvertebrate community of Sawmill Creek is chracteristic of streams receiving organic pollution. The fauna is not diverse and contains primarily blackflies, midges, isopods, flatworms, and segmented worms. Cleanwater invertebrates, e.g. mayflies and stoneflies, are rare or conspicuously absent. The fish community of the stream indicates similar conditions. Creek chubs greatly dominate the depauperate community, which consists of a few species of minnows, sunfishes, and catfish.

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4. ENVIRONMENTAL CONSEQUENCES OF THE PROPOSED ACTIONS AND ALTERNATIVES

4.1 AIR QUALITY

4.1.1 Impacts

4.1.1.1 During Interim Period

Boiler No. 5 will burn coal without the required pollution-control equipment for a period of about one year. A study made for ANL has shown that the uncontrolled emissions of the boiler will not cause or contribute to a violation of the primary National Ambient Air Quality Standards (NAAQS) for particulates, or to a violation of the primary or secondary NAAQS for SO_2 (PEDCO 1980a, 1980b). However, the area is, and will continue to be, in violation of the secondary NAAQS for particulates. PEDCO (1980a) projected maximum increases to ambient air concentrations of TSP from Boiler No. 5 as follows:

Ash Content	Annual Geometric Mean	24-Hour Average
6.0% ash coal	1.5 μg/m^3	12 μg/m^3
7.6	2.1	16
10	2.8	22

EPA has established a 24-hour average of 10.4 μg/m^3 as "de minimis" for PSD nonattainment areas. For comparison purposes, Boiler No. 5's impact would be 12-22 μg/m^3 for less than one year. Given the proximity to the "de minimis" level and the short duration of the uncontrolled emissions, the contribution to the existent violation of the secondary TSP standard is clearly insignificant. DOE has petitioned the USEPA for a Delayed Compliance Order (DCO) to allow operation despite the TSP air-quality violation; the DCO was published for comment in the Federal Register of 17 November 1980. The Illinois Pollution Control Board has been petitioned for a variance from the state TSP air-quality standard for the duration of the precontrol year; a decision on the petition is expected on 4 December 1980.

4.1.1.2 With Scrubbers Installed

The following assessment assumes treatment of the flue gas from Boiler No. 5 by a dry-SO_2-scrubbing system operating at 70% removal efficiency and a baghouse operating at 99% particulate-matter-removal efficiency. In addition, Boiler No. 1 will soon be converted to a coal-fired fluidized-bed combustion unit. Its emissions and impacts are also included in the following assessment.

In addition to meeting the NAAQS listed in Table 3.6, the conversions of Boilers No. 1 and No. 5 must also comply with the increment-consumption aspects of the "Prevention of Significant Deterioration" (PSD) Regulations (USEPA 1980). These regulations apply to areas that are in attainment with the NAAQS and establish a significant constraint on any increase of particulate and SO_2 levels in those areas. Every point in the country is classified into one of three categories: Class I areas correspond to those in which very little deterioration of air quality is to be allowed, Class III areas are those in which greatest deterioration will be allowed, and Class II is intermediate. Class I areas are national parks, monuments, etc. The rest of the country is currently designated Class II. There are no Class I areas in the vicinity of Chicago. The baseline pollutant concentrations are defined by monitoring (see Sec. 3.3) at the time of the first permit application (Alabama Power vs. Costle - proposed legislation), and the maximum allowable increases in particulate matter and SO_2 are specified for each classification. The increments are given in Table 4.1.

The CRSTER dispersion model (USEPA 1977) was used to estimate the long- and short-term air-quality impacts from fuel conversions of Boilers No. 1 and No 5. The model was designed to simulate atmospheric-dispersion processes for calculating ambient concentration levels of various atmospheric contaminants emitted from a single point source. The addition of these predicted concentrations to ambient background levels determined from air-monitoring data determines compliance with air-quality standards.

Table 4.1. Maximum-Allowable Pollutant Increases by Class ($\mu g/m^3$)[a]

Pollutant	Averaging Time	Increment: Class I	Class II	Class III	Significant Level[b]
Particulate matter	1 year	5	19	37	-
	24 hours	10	37	75	10.4
Sulfur dioxide	1 year	2	20	40	-
	24 hours	5	91	182	14.6
	3 hours	25	512	700	-

[a]See text for class definitions.

[b]From USEPA (1980).

The CRSTER model is composed of two parts: (1) a plume-rise model, which estimates the effective release height of the plume from the stack, and (2) a diffusion model based on the Gaussian plume equation, which calculates the downwind dispersion of the plume. Both these models attempt to simulate the actual atmospheric-pollutant transport under a simplifying set of assumptions.

The model requires a specific set of input data and yields output data consisting of pollutant concentrations for specific averaging times and receptor locations. It requires information about the source, site, and meteorology. Source factors relate to stack characteristics, such as physical height and gas temperature, and to emissions (see Table 4.2), and site factors deal with the effect of terrain (see Table 4.3).

The applicable Illinois emission standards for Boiler No. 5 for particulates and SO_2 are 0.04 kg/billion J (0.1 lb/million Btu) and 0.8 kg/billion J (1.8 lb/million Btu), respectively, as obtained from the Plant Systems Division at ANL. Boiler No. 5 meets the emission limits for both particulates and SO_2. It is not subject to NO_x emission limits because it is rated below 2.6×10^{11} J/h (250 million Btu/h).

Table 4.2. Stack Characteristics and Pollutant Emissions from Boilers No. 1 and No. 5

Parameter	Pollutant	Max	Avg
Heat input rate (No. 5)		2.2×10^{11} J/h	1.3×10^{11} J/h
Stack height		46.9 m	46.9 m
Stack diameter		1.8 m	1.8 m
Gas exit velocity		8.1 m/s	6.0 m/s
Temperature		455 K	430 K
	SO_2 (No. 5)	31.6 g/s	18.6 g/s
	SO_2 (No. 1)	18.4 g/s	11.2 g/s
	TSP (No. 5)	1.5 g/s	1.0 g/s
	TSP (No. 1)	1.5 g/s	0.9 g/s
	NO_x (No. 5)	20.4 g/s	10.0 g/s
	NO_x (No. 1)	10.8 g/s	6.5 g/s
	CO (combined)	2.2 g/s	2.7 g/s

Assuming a peak steam demand of 45,000 kg/h (100,000 lb/h), emission rates of particulates, NO_x, and SO_2 for Boiler No. 1 are expected to be no more than 0.04 kg/billion J (0.1 lb/million Btu), 0.3 kg/billion J (0.7 lb/million Btu), and 0.5 kg/billion J (1.2 lb/million Btu), respectively, which are the New Source Performance Standards (NSPS) for fossil-fuel-fired steam generators. These standards are not applicable, as discussed later; but, as there are no current NSPS for fluidized-bed boilers, they will be used for comparison purposes. Compliance with these standards indicates that Boiler No. 1 will be able to comply with all applicable state emission limits and State Implementation Plan (SIP) emission limits.

Table 4.3. Site Factors Used as Input to the CRSTER Model - Receptor Elevations (m MSL)[a]

Direction (degrees)	Distance (km)				
	0.5	1.0	2.0	5.0	10.0
10	201.2	204.2	208.8	221.0	228.6
20	205.7	213.4	205.7	216.4	221.0
30	205.7	214.9	210.3	216.4	210.3
40	208.8	216.4	217.9	214.9	207.3
50	210.3	214.9	219.5	216.4	195.1
60	210.3	213.4	217.9	219.5	205.7
70	208.8	216.4	214.9	213.4	184.4
80	207.3	213.4	217.9	205.7	190.5
90	202.7	210.3	214.9	182.9	213.4
100	199.6	208.6	210.3	182.9	219.5
110	199.6	202.7	213.4	185.9	181.4
120	199.6	201.2	213.4	205.7	201.2
130	201.2	205.7	207.3	185.9	221.0
140	198.1	198.1	202.7	198.1	210.3
150	199.6	201.2	190.5	195.1	224.0
160	205.7	207.3	185.9	202.7	221.0
170	205.7	210.3	198.1	208.8	216.4
180	205.7	214.9	165.9	189.0	216.4
190	207.3	217.9	205.7	182.9	198.1
200	213.4	213.4	216.4	179.8	225.6
210	216.4	214.9	217.9	179.8	225.6
220	216.4	221.0	228.6	207.3	178.3
230	213.4	221.0	225.6	222.5	179.8
240	214.9	221.0	228.6	222.5	213.4
250	216.4	224.0	230.1	222.5	219.5
260	219.5	225.6	227.1	224.0	213.4
270	219.5	224.0	225.6	225.6	213.4
280	213.4	219.5	225.6	225.6	196.6
290	214.9	219.5	224.0	234.7	213.4
300	211.8	222.5	219.5	231.6	225.6
310	211.8	219.5	221.0	225.6	225.6
320	210.3	216.4	221.0	227.1	225.6
330	207.3	213.4	221.0	239.3	228.6
340	202.7	204.2	224.0	237.7	219.5
350	205.7	205.7	221.0	234.7	219.5
360	205.7	205.7	214.9	226.6	236.2

[a]Plant elevation, 213.4 m MSL.

Meteorological requirements are dispersion properties of the atmosphere at any particular time in terms of joint occurrence of specific conditions of atmospheric stability, mixing height, and wind speed and direction.

Ambient air-quality concentrations are calculated in the same time scales as given in the NAAQS. The concentrations are determined by year and the printout includes highest and second-highest 1-hour, 3-hour, and 24-hour averages, and annual mean, at a set of 180 receptors around the source. Meteorological data were obtained from Chicago Midway Airport, the nearest first-order National Weather Service Station (20 km or 12 mi ENE), and are representative of the ANL site (ANL 1967). Five years of data (1960-1964) are used to provide a good statistical analysis.

With regard to TSP, the PSD increment is not appropriate because monitored data show that air quality is presently above the NAAQS specification (see Table 3.6). The entire SO_2 increment is available for all three averaging times.

TSP and SO_2 concentrations calculated by the CRSTER model are given in Table 4.4. The maximum annual-mean ground-level concentration for TSP is predicted as 0.29 μg/m^3 at about one kilometer northeast (40°) of the plant. The second-highest 24-hour TSP average is predicted as 3.18 μg/m^3 at about two kilometers southwest (220°) of the plant. These predicted increments in ground-level TSP concentration show an insignificant impact on air quality of the surrounding area.

SO_2 concentrations from the two boilers predicted by the model show the highest ground-level concentrations to occur between one and two kilometers from the plant. The predicted maximum annual-mean concentration is 4.50 μg/m^3, the second-highest 24-hour average is 53.1 μg/m^3, and the second-highest 3-hour average is 157.1 μg/m^3. All values are well below their respective PSD increments of 20 μg/m^3, 91 μg/m^3, and 512 μg/m^3.

Although the conversions of the boilers consume over 50% of the 24-hour PSD increment, it does not necessarily follow that less than 50% of the 24-hour increment remains. It is possible to situate a future source in the area in

Table 4.4. Contributions to Ground-Level Concentrations After Conversions of Boilers No. 1 and No. 5 (μg/m^3) - Argonne CRSTER Data

	TSP		SO_2		
Year[a]	Annual Mean	Second-Highest 24-h Avg	Annual Mean	Second-Highest 24-h Avg	Second-Highest 3-h Avg
1960	0.22 @ 1 km & 23°	2.97 @ 2 km & 220°	3.43 @ 1 km & 230°	49.5 @ 2 km & 220°	139.5 @ 1 km & 270°
1961	0.23 @ 1 km & 230°	3.06 @ 2 km & 220°	3.60 @ 1 km & 230°	51.1 @ 2 km & 220°	148.1 @ 1 km & 300°
1962	0.28 @ 2 km & 230°	3.03 @ 2 km & 220°	4.35 @ 2 km & 230°	50.5 @ 2 km & 220°	150.5 @ 1 km & 280°
1963	0.29 @ 1 km & 40°	3.18 @ 2 km & 220°	4.50 @ 1 km & 40°	53.1 @ 2 km & 220°	157.1 @ 2 km & 40°
1964	0.27 @ 1 km & 30°	2.64 @ 2 km & 220°	4.23 @ 1 km & 30°	44.0 @ 2 km & 220°	149.6 @ 1 km & 270°

[a]Years from which meteorological data were taken to obtain CRSTER results.

such a way as to eliminate the possibility of having a coincident point of maximum impact from both sources over a 24-hour period. Their impacts would not be mutually exclusive; therefore, the incremental change in ground-level pollution concentrations from the two sources could not be simply added together to assess the cumulative impact. Rather, a multisource model would have to be used taking into account times when impacts overlap and when they do not. It should be noted that during the first year of operation of Boiler No. 5, that source will consume a larger portion of the increment than it will subsequently. However, Boiler No. 1 will not yet have been replaced, so total SO_2 emissions will in fact be less in later years when both boilers are using coal.

The predicted maximum annual-mean ground-level NO_x concentration is 62.5 $\mu g/m^3$, and occurs one kilometer from the stack. At distances greater than five kilometers, the contributions from the boilers fall below 10.4 $\mu g/m^3$ and are considered insignificant (USEPA 1980).

The predicted maximum ground-level CO concentrations resulting from coal combustion at Boilers No. 1 and No. 5 are 8.48 $\mu g/m^3$ (8-h) and 16.2 $\mu g/m^3$ (1-h) and are considered insignificant (USEPA 1980).

Some concern exists pertaining to aerodynamic downwash. If a stack is not tall enough, the plume may become entrained in the recirculatory airflow generated on the lee side of the building. When this happens, very high ground-level pollutant concentrations may result. USEPA has recently proposed regulations involving stack heights for new facilities (USEPA 1979a). The good-engineering-practice stack height for the boiler house is 56.4 m (185 ft), about 9 m (30 ft) higher than the present stack height (Brubaker 1979). Under downwash conditions (wind speeds greater than 40 m/s or 90 mph) the instantaneous ground-level concentration may reach 2000 $\mu g/m^3$ (Noll 1976). Meteorological conditions of this type coincide with maximum boiler loading during less than 50 hours each year.

Emissions from the coal-handling facility and coal pile are expected to be minor and transitory. Coal-laden rail cars are driven into a small shed where they are unloaded by opening the hopper doors and shaking the car. Trucks may be emptied directly into hoppers or dumped in the storage area. As the coal is dumped, it is sprayed with a foam surfactant to reduce fugitive-dust emissions. The surfactant provides up to 99.99% dust control (Siebert Engrs 1980). The coal conveyor is completely enclosed, which also minimizes fugitive-dust emissions.

The coal pile will average 18,000 t (20,000 tons) and occupy an area of about 0.56 ha (1.38 acres), which is less than the total storage area. The average emission rate is estimated to be 46 mg/s (Blackwood and Wachter 1977). This is equivalent to an ambient air concentration of less than 1.0 $\mu g/m^3$ at a distance of one kilometer (Turner 1970). Use of the surfactant during periods of adding or removing coal from the storage pile will keep the fugitive emissions low.

Boiler No. 5 is not subject to the PSD requirements of best available control technology and preconstruction review. This is because it will be using an alternative fuel that it was capable of accommodating before 6 January 1975 [40 CFR 51.24(b)(2)(iii)(e)(1)]. It is also not subject to the Clean Air Act requirements for nonattainment areas (as to TSP) because it will be using an alternative fuel that it was capable of accommodating before 21 December 1976 [40 CFR 51.18(j)(1)(vi)(c)(5)(i)]. New-source performance standards for fossil-fuel-fired steam generators are not applicable because Boiler No. 5 has a heat input rate of less than 2.6×10^{11} J/h (250 million Btu/h) [40 CFR 60.40(a)(1)].

Thus, the only air-quality regulations to be met for Boiler No. 5 during operation with and without controls are the SIP emission limits, the PSD consumption increments, and the state emission limits. As shown above, during operation with scrubbers, all these standards are met. Potential problems that could arise during the precontrol year are insignificant, particularly in view of their intensities and the short time during which precontrol conditions will exist.

The heat input rate of Boiler No. 1 will be less than 2.6×10^{11} J/h (250 million Btu/h). The source will not emit 230 t (250 tons) or more of any pollutant. Therefore, it does not have to satisfy EPA nonattainment regulations or the PSD requirements of best available control technology and preconstruction review. There are no NSPS for fluidized-bed combustion boilers. The SIP emission limits, the PSD increment rules, and the state emission limits all will be met, as discussed above.

In addition to the major pollutants (SO_2, NO_x, particulates) emitted from Boiler No. 1 fluidized-bed operation, various organic and inorganic emissions may occur. Emissions would be either gaseous or contained in the particulates. Because combustion temperatures in the fluidized bed are lower than those in conventional coal burning, and the limestone can act as a trap, the emitted levels of most of the pollutants will be lower than for conventional firing. A list of potential pollutants and their estimated or theoretically calculated concentrations are shown in Table 4.5 (Fennelly et al. 1977). After dilution in the atmosphere, these levels will be very low and probably

Table 4.5. Potential Pollutants from Coal-Fired Fluidized-Bed Combustion and Their Estimated Concentrations[a]

Pollutant	Estimated Concentration[b]
Gas phase[c]	
CH_4, CO, HCl, SO_2, NO	100 ppm
SO_3, C_2H_4, C_2H_6	10 ppm
HF, HCN, NH_3, $(CN)_2$, COS, H_2S, H_2SO_4, HNO_3, F, Na	1 ppm
Diolefins, aromatic hydrocarbons, phenols, azoarenes, As, Pb, Hg, Br, Cr, Ni, Se, Cd, U, Be	1 ppb
Carboxylic acids, sulfonic acids, polychlorinated biphenyls, alkynes, cyclic hydrocarbons, amines, pyridines, pyroles, furans, ethers, esters, epoxides, alcohols, ozone, aldehydes, ketones, thiophenes, mercaptans	0.1 ppb
Solid phase[d]	
Al, Ca, Fe, K, Mg, Si, Ti, Cu, Zn, Ni, U, V	1 ppm
Ba, Co, Mn, Rb, Sc, Sr, Cd, Sb, Se, Ca	1 ppb
Eu, Hf, La, Sn, Ta, Th	0.1 ppb

[a]Adapted from Fennelly et al. (1977).

[b]Estimates are probably good to within an order of magnitude.

[c]Includes gases, vapors, and very fine particulates (< 2 μm).

[d]Includes agglomerated bed material and coarse particulates (> 2 μm), which should be collected by conventional particle-control devices.

negligible; however, the health effects and ultimate fate in the environment of the pollutants are not fully defined at this time and should be the subject of additional research.

4.1.2 Mitigating Measures

Pollution-abatement equipment will be installed on Boiler No. 5 to reduce the particulate and SO_2 emissions from the flue gas. The control equipment will consist of a dry SO_2 scrubber and fabric filter, which will be retrofitted to the boiler in about one year, depending on the time necessary for delivery and installation of new equipment.

Fabric filters have efficiencies of 99% or better when collecting particles greater than 6.5 mm and can remove substantial quantities of 0.01-mm particles (Work and Warner 1976). The principal methods of collection are interception, impaction, and diffusion of the particles onto the fibers of a woven fabric.

SO_2 will be removed from flue gas with the use of a dry scrubber (USEPA 1979c). The term "dry" is somewhat of a misnomer because the solvent, usually a lime slurry, is sprayed as a liquid into the flue gas. The SO_2 reacts with the lime slurry, resulting in the formation of calcium sulfite and calcium sulfate. The droplets are small enough that the water evaporates and the small calcium-salt particles are left suspended in the gas stream. These particles are captured in a collection device, in this case a baghouse. The SO_2-removal efficiency of this system can be anywhere from 60% to 85% depending on the Ca/S ratio, sulfur content of the coal, liquid-to-gas ratio, and type and weave of fabric used in the baghouse (USEPA 1979c). Stack- and ambient-air monitoring will be performed as required by the USEPA.

Mitigative measures regarding coal handling and storage are discussed in Section 4.1.1.

In Boiler No. 1, the limestone in the bed will immobilize up to 90% of the SO_2. NO_x will be held to a low value by the low burning temperature, and particulates will be controlled by a series of mechanical collectors and a fabric (baghouse) filter.

4.2 LAND RESOURCES

The principal impact to land resources resulting from the proposed action will be due to the reuse of a formerly disturbed area for the coal-storage facility. The destruction of this old-field plant community will result in the loss of small-animal habitat, and fallow-deer (Dama dama) forage. Although the loss of this plant community and wildlife habitat is unavoidable, its loss should not have a significant impact on land resources, as a number of similar communities exist elsewhere on the ANL site and in the surrounding area.

An alternative coal-storage area that would have occupied several hectares of the Sawmill Creek floodplain has been rejected because of the possibility of ecological damage.

4.3 HISTORICAL AND ARCHEOLOGICAL RESOURCES

4.3.1 Onsite Impacts

A cultural-resource survey has been made of the immediate area surrounding the boiler plant where coal will be stored and other improvements made. Based on several testing procedures, it was determined that this area is composed of fill. Consequently, any cultural resources that might be present would be deeply buried and unaffected by the proposed actions associated with the boiler conversion. Moreover, the construction and operational phases of this project are not expected to affect the other prehistoric and historic sites that have been identified on the ANL property.

The office of the Illinois State Historic Preservation Officer is reviewing the results of the 1978 and 1979 ANL cultural-resource studies, and will be asked to comment on the results of the 1980 study of the boiler facility.

4.3.2 Offsite Impacts

Should the construction and operational phases of this project require the management of additional lands offsite, such as railroad rights-of-way and storage areas near barge docks, these new areas should be studied to determine if cultural resources are present. A cultural-resource survey and site-evaluation program may be necessary.

4.4 WATER RESOURCES

4.4.1 Impacts on Surface Water

4.4.1.1 Current Conditions

The present impacts on surface waters arise from runoff from a small (2700-t or 3000-ton) low-sulfur-coal stockpile, and from discharges of component-cooling water from the boiler house and boiler blowdown (NPDES permit, discharge point 002). The two discharges will be unchanged in any of the alternatives.

The coal pile has been undisturbed since 1973 and no monitoring of runoff has been done. The runoff flows to Sawmill Creek, with an unknown but probably small amount penetrating the ground. The quantity of runoff is probably insufficient to affect Sawmill Creek to any detectable degree.

The component-cooling water is taken from the Sanitary and Ship Canal and used after lime-alum flocculation/settling treatment. The water is originally of a very low quality, and is improved somewhat by the treatment. The annual volume is 4.9×10^4 m^3/yr (1.3×10^7 gal/yr) or 95 L/min (25 gpm). Small quantities of corrosion products (iron) enter the water during passage; however, the volume of water is so low and the quality of Sawmill Creek water is so poor that no detectable effects will occur from discharge point 002.

The boiler blowdown is about 3.4×10^4 m^3/yr (9×10^6 gal/yr) or 64 L/min (17 gpm). The major impurities are 1000 mg/L of dissolved solids consisting mainly of sulfate, chloride, sodium, and calcium ions. These ions are common components of natural waters, and the small quantities added are quickly diluted to harmless levels. No ash or sludges are produced by the present system.

4.4.1.2 Burning High-Sulfur Coal

Impacts on surface waters could occur through the runoff (after treatment) of rainwater and melted snow that has percolated through the stored coal piles and through the ash and scrubber sludge beds. Impacts could also arise from the settling and rainwater scavenging of airborne pollutants from the smokestack. The airborne pollutants are discussed in Section 4.1.

As stated in Sections 2.4.2 and 4.1.1, about 18,000 t (20,000 tons) of coal will occupy an area of about 0.56 ha (1.38 acres). The average annual precipitation in Illinois is about 870 mm (34 in), so the annual coal-pile runoff will be about 5000 m^3/yr (1.3 x 10^6 gal/yr) or 9.2 L/min (2.4 gpm). The composition of the runoff will vary greatly depending on the type and degree of cleaning of the coal, the age of the coal, and the structure of the coal pile. Table 4.6 shows the runoff composition of some typical coals; ANL will probably use Illinois coal (under Interior Eastern in the table) or Appalachian coal. Table 4.7 shows the effect of aging on the coal runoff.

Of concern are the high levels of dissolved and suspended solids, the low pH value, and the high levels of iron and sulfate, particularly in aged coals. Among the components of organic carbon are a number of polynuclear aromatic hydrocarbons, which are potential carcinogens. As stated in Section 2.4.2.3, runoff will be pumped to the lime pond where precipitation, neutralization, and settling will occur. In view of the low average flows and the treatment, no detectable effects on surface water should occur. The pond outlet is presently monitored for suspended solids, total solids, phosphorus, temperature, pH, and flow in accordance with the NPDES permit for location 002 at ANL.

If the alternative for onsite disposal of ash were used, runoff would also occur from about 3500 t/yr (4000 tons/yr) of mixed bottom and coarse fly ash. The bottom ash is a dense ceramic material of overall composition similar to clay. The material is resistant to leaching and unlikely to cause water pollution. The fly ash from the cyclone will be coarse compared to that obtained from pulverized-coal systems and also unlikely to pollute. The permit from the Illinois EPA for the present sanitary landfill would also have

Table 4.6. Average Effluent Concentrations in Runoff vs. Coal Region (g/m^3 except pH)[a]

	Region					
Effluent Parameter	Appalachian	Great Northern Plains	Interior Eastern	Interior Western	Western	Southwestern
Total suspended solids	1521	1282	1264	1853	2486	1538
Total dissolved solids	259	430	1136	5539	1900	356
Sulfate	66	1598	648	4860	240	190
Iron	3.1	1.5	9.1	1131	8.2	5.5
Manganese	0.03	0.14	0.44	17.9	0.4	0.04
Free silica	12.3	NDL[b]	0.8	86.3	NDL	NDL
Cyanide	<0.001	NDL	0.002	NDL	NDL	NDL
BOD_5	<5.0	<7.5	NDL	<1.2	<2.5	<7.5
COD	1407	1324	1556	1053	1826	769
Nitrate	0.12	0.14	0.33	0.09	1.8	0.16
Total phosphate	NDL	NDL	NDL	NDL	NDL	NDL
Antimony	2.1	NDL	7.5	10.3	14.0	6.5
Arsenic	23	1.8	4.1	10.1	5.6	4.1
Beryllium	NDL	NDL	NDL	NDL	NDL	NDL
Cadmium	NDL	NDL	NDL	0.05	0.005	NDL
Chromium	NDL	NDL	NDL	0.03	0.04	NDL
Copper	0.02	NDL	NDL	2.2	NDL	0.02
Lead	0.05	0.05	0.06	0.33	0.07	0.05
Nickel	0.06	0.02	0.09	10.2	0.05	0.03
Selenium	23.8	NDL	12.5	25.2	15.0	21.5
Silver	NDL	NDL	NDL	NDL	NDL	NDL
Zinc	0.008	0.17	0.14	25.0	0.15	0.04
Mercury	<0.001	0.003	NDL	0.004	0.005	0.002
Thallium	NDL	NDL	NDL	NDL	NDL	NDL
pH[c]	6.28	6.93	7.62	2.81	7.24	6.60
Chloride	0.33	NDL	NDL	2.3	NDL	NDL
Total organic carbon	251.7	373.2	380.1	90.5	318.4	158.7

[a]From Monsanto Research Corp., "Source Assessment: Water Pollutants from Coal Storage Areas," NTIS, PB-285 420, May 1978.

[b]No detectable level.

[c]Negative logarithm of hydrogen-ion concentration.

to include the disposal of ash. The conditions of the permit will require that leach tests be performed to ascertain that harmful pollutants are not being released. The landfill does not have a clay or membrane liner; however, these are not required by EPA for ash disposal.

About 135 t/yr (150 tons/yr) of fine fly ash will pass through the cyclones and be collected in a baghouse. In the dry-scrubber installation, the fly ash will be a small part of the total mass collected, hence, dry-scrubber fly ash will be considered together with dry-scrubber sludge. The unmixed fly ash collected in the wet-scrubber system should be generally similar in properties

Table 4.7. Effluent Concentrations vs. Rainfall Frequency for Aged and Fresh Coals (g/m^3 except pH)[a]

	Rainfall Frequency					
	First Run Last Rainfall >30 days		Third Run Last Rainfall 14 days		Second Run Last Rainfall 1 day	
Effluent Parameter	Fresh Coal	Aged Coal	Fresh Coal	Aged Coal	Fresh Coal	Aged Coal
Total suspended solids	724	1656	1206	1943	5396	5176
Total dissolved solids	200	16372	375	4836	336	5488
Sulfate	67	14472	58	3899	121.5	4896
Iron	0.4	3099	2.6	1400	7.7	990
Manganese	NDL[b]	55	0.05	13	0.01	16
Free silica	NDL	436	0.6	3.3	94.7	NDL
Cyanide	NDL	NDL	0.006	0.006	NDL	0.01
BOD_5	<5	NDL	NDL	NDL	<25	<15
COD	591	1092	1079	988	4.6	2876
Nitrate	0.04	NDL	0.2	0.14	0.14	0.16
Total phosphate	NDL	NDL	NDL	NDL	NDL	NDL
Antimony	NDL	11	NDL	0.009	15	37
Arsenic	0.14	26	0.02	0.016	3.4	10.3
Beryllium	NDL	NDL	NDL	NDL	NDL	NDL
Cadmium	NDL	0.9	NDL	0.3	NDL	0.3
Chromium	NDL	NDL	NDL	0.08	NDL	NDL
Copper	NDL	7.0	0.06	2.0	0.17	2.2
Lead	0.07	0.5	0.05	0.5	0.11	0.3
Nickel	0.06	33	0.05	6.5	0.14	9.7
Selenium	0.08	59	NDL	NDL	87	67
Silver	NDL	NDL	NDL	NDL	NDL	NDL
Zinc	NDL	107	0.05	31	0.04	31
Mercury	0.02	0.009	NDL	NDL	NDL	NDL
Thallium	NDL	NDL	NDL	NDL	NDL	NDL
pH[c]	6.4	2.4	5.9	2.7	6.4	2.6
Chloride	NDL	8.9	NDL	1.8	2.3	1.0
Total organic carbon	174	39.2	397	306	63.2	3.1

[a]From Monsanto Research Corp., "Source Assessment: Water Pollutants from Coal Storage Areas," NTIS, PB-285 420, May 1978.

[b]No detectable level.

[c]Negative logarithm of hydrogen-ion concentration.

to the fine fly ash from pulverized-coal-burning systems. Of the ANL ash, the fine material has the highest surface area, the highest content of many toxic trace elements, and, as a consequence of the high surface area, the greatest potential for leaching. Typical compositions of the major species in fly-ash leachates from a variety of coals are given by Coltharp et al. (1979), (table on p. 6-14). The pH may be highly alkaline, and high levels of solids, calcium, and sulfate may occur. Data for other fly-ash leachates, which have strongly acidic pH values, are also given by Coltharp et al. (1979), (table on pp. 6-23 and -24. These tables also show the amounts of trace elements in a number of leachates. The properties of the leachates from different sources vary greatly and, even from the same source, large variations may occur.

Because the eluates from different fly ashes vary so greatly, it is difficult to specify the characteristics of the ANL fly-ash runoff. Many types of fly ash do not have serious contaminant problems, and the amount of fine fly ash from ANL is quite small. Consequently, if reasonable precautions are taken to minimize water access to the ash, disposal in a sanitary-waste disposal area could be practicable for the ANL fine fly ash. Monitoring is presently required by terms of the Illinois EPA landfill permit to ensure that no harmful effluents are released. If the pollutant level is high in the leachate, disposal in lined and covered beds could be necessary; however, this has not generally been necessary for ash disposal.

The effects of scrubber-sludge runoff on surface waters will depend on the scrubbing method, the fly-ash content, the initial liquid content, and the disposal method. Typical concentrations of major chemical species in scrubber liquids are shown in Table 4.8, and trace-element concentrations in Table 4.9. A comparison with EPA drinking-water standards is also shown in the tables, and it can be seen that many species are above the standards. However, Resource Conservation and Recovery Act (RCRA) regulations consider extracts containing up to 100 times the drinking-water standards as nonhazardous (40 CFR 261). The concentrations of some of these substances will decrease rapidly once the initial scrubber liquids are washed away; nevertheless, the sludges present a potential water-pollution hazard.

The ANL specifications for an alternate wet-scrubber system call for a minimum of 70% solids, or fixed sludges. If the fixation can reduce the permeability of the sludge and harden it sufficiently to allow a low-permeability earth cover to be placed over it, the impacts should be reduced to an acceptable level.

Very little data are presently available on the properties of dry sludge (the selected type). Inasmuch as it is dimensionally stable and does not contain

Table 4.8. Ranges of Concentration of Major Species in FGD Sludge, Liquors, and Elutriates (mg/L except pH, conductance, and turbidity)[a]

Species	Aerospace[b] Eastern Coal Range	Aerospace[b] Eastern Coal Median	Aerospace[b] Western Coal Range	Aerospace[b] Western Coal Median	USEPA[c] Range	All Sources Range	USEPA Secondary Drinking-Water Standards
Alkalinity (as $CaCO_3$)	--	--	--	--	41 to 150	41 to 150	
Calcium	470 to 2,600	700	420 to ~45,000[d]	720	520 to 3,000	420 to ~45,000[d]	
COD	--	--	--	--	60 to 390	60 to 390	
Chloride	470 to 5,000	2,300	1,700 to 43,000[d]	--	--	470 to 43,000[d]	250
Magnesium	--	--	--	--	3.0 to 2,750	3.0 to 2,750	
pH	7.1 to 12.8	--	2.8 to 10.2	--	3.04 to 10.7	2.8 to 12.8	6.5 to 8.5
Potassium	--	--	--	--	5.9 to 32	5.9 to 32	
Sodium	36 to 20,000[e]	118	1,650 to ~9,000[e]	--	14.0 to 2,400	14.0 to 20,000[e]	
Sulfite	--	--	--	--	0.8 to 3,500	0.8 to 3,500	
Sulfate	720 to 30,000[e]	2,100	2,100 to 18,500[e]	3,700	720 to 10,000	720 to 30,000[e]	250
TDS	2,500 to 70,000[e]	7,000	5,000 to 95,000[d]	12,000	3,200 to 15,000	2,500 to 95,000[d,e]	500
Conductance (mho/cm)	--	--	--	--	0.003 to 0.015	0.003 to 0.015	
Turbidity (JTU)	--	--	--	--	<3 to <10	<3 to <10	

[a] Adapted from Duvel et al. (1979).

[b] Source: Rossoff, J. and Rossi, R.C., "Disposal of By-Products from Non-Regenerable FGD Systems: Initial Report," Aerospace Corporation, EPA 650/2-74-037a, May 1974.

[c] Source: Bornstein, et al., "Re-Use of Power Plant Desulfurization Waste Water," EPA 600/2-76-024, USEPA, Corvallis, OR, February 1976.

[d] The highest levels shown are single measurements for a western-limestone scrubbing system.

[e] The highest levels shown reflect single measurements on an unwashed double-alkali filter cake.

Table 4.9. Ranges of Concentration of Trace Elements in FGD Sludge, Liquors, and Elutriates (mg/L)[a]

Species	Radian[b] Range	Radian[b] Mean	Aerospace[c] Eastern Coal Range	Aerospace[c] Eastern Coal Median	Aerospace[c] Western Coal Range	Aerospace[c] Western Coal Median	USEPA[d] Range	All Sources Range	USEPA Drinking-Water Standards
Aluminum	--	--	--	--	--	--	0.03 to 0.3	0.03 to 0.3	
Antimony	0.09 to 2.9	0.2	0.46 to 1.6	1.2	0.09 to 0.22	0.16	0.09 to 2.3	0.09 to 2.9	
Arsenic	0.004 to 0.3	0.009	<0.004 to 1.8	0.02	<0.004 to 0.2	0.009	<0.004 to 0.3	<0.004 to 0.3	0.05
Barium	--	--	--	--	--	--	--	--	1
Beryllium	0.0006 to 0.14	0.013	<0.0005 to 0.05	0.014	0.0006 to 0.14	0.013	<0.002 to 0.14	<0.0005 to 0.14	
Boron	0.9 to 46	e	41	41	8.0	8.0	8.0 to 46	0.9 to 46	
Cadmium	0.002 to 0.044	0.032	0.004 to 0.1	0.023	0.011 to 0.044	0.032	0.004 to 0.11	0.002 to 0.11	0.01
Chromium	0.005 to 0.4	0.08	0.001 to 0.5	0.02	0.024 to 0.4	0.08	0.01 to 0.5	0.001 to 0.5	0.05
Cobalt	0.1 to 0.7	e	<0.002 to 0.1	0.35	0.1 to 0.17	0.14	0.10 to 0.7	<0.002 to 0.7	
Copper	0.002 to 0.6	0.20	0.002 to 0.4	0.015	0.002 to 0.6	0.20	<0.002 to 0.2	<0.002 to 0.6	1[f]
Fluoride	0.7 to 3.0	1.5	1.4 to 70	3.2	0.7 to 3.0	1.5	--	0.7 to 70	1.4 to 2.4
Iron	0.02 to 8.1	e	0.02 to 0.1	0.026	0.42 to 8.1	4.3	0.02 to 8.1	0.02 to 8.1	0.3[f]
Lead	0.001 to 0.4	0.016	0.002 to 0.55	0.12	0.0014 to 0.37	0.016	0.01 to 0.4	0.001 to 0.55	0.05
Lithium	--	--	--	--	--	--	--	--	
Manganese	0.007 to 2.5	0.74	<0.01 to 9.0	0.17	0.007 to 2.5	0.74	0.09 to 2.5	0.007 to 9.0	0.05[f]
Mercury	0.0004 to 0.07	<0.01	0.0009 to 0.07	0.001	<0.01 to 0.07	0.01	0.0004 to 0.07	0.0004 to 0.07	0.002
Molybdenum	0.07 to 6.3	e	5.3	5.3	0.91	0.91	0.91 to 6.3	0.07 to 6.3	
Nickel	0.005 to 1.5	0.09	0.03 to 0.91	0.13	0.005 to 1.5	0.09	0.05 to 1.5	0.005 to 1.5	
Selenium	0.001 to 2.2	0.14	0.005 to 2.7	0.11	<0.001 to 2.2	0.143	<0.001 to 2.2	<0.001 to 2.7	0.01
Silver	0.005 to 0.6	e	--	--	--	--	0.005 to 0.6	0.005 to 0.6	0.05
Tin	3.1 to 3.5	e	--	--	--	--	3.1 to 3.5	3.1 to 3.5	
Uranium	--	e	--	--	--	--	--	--	
Vanadium	0.001 to 0.67	e	--	--	--	--	0.001 to 0.67	0.001 to 0.67	
Zinc	0.03 to 2.0	0.18	0.01 to 27	0.046	0.028 to 0.88	0.18	0.01 to 0.35	0.01 to 27	5[f]

[a] Adapted from Duvel et al. (1979).

[b] Source: Jones, B.F., et al., "Evaluation of the Physical Stability and Leachability of Flue Gas Cleaning Wastes," Radian Corporation, EPRI FP 671, Volume 2, 1978.

[c] Source: Rossoff, J. and Rossi, R.C., "Disposal of By-Products from Non-Regenerable FGD Systems: Initial Report," Aerospace Corporation, EPA 650/2-74-037a, May 1974.

[d] Source: Bornstein, et al., "Re-Use of Power Plant Desulfurization Waste Water," EPA 600/2-76-024, USEPA, Corvallis, OR, February 1976.

[e] Sufficient data were not available for the meaningful calculation of a mean.

[f] Secondary standard.

bound water, impacts can be controlled by the use of an impermeable (clay) cover above the sludge. Because the dry sludge can be compacted and covered, and does not contain free water, the dry system should be environmentally preferable to wet-sludge systems.

4.4.2 Impacts on Groundwater

Any of the contaminated liquids entering surface water could also potentially pollute groundwater by permeating the earth surface. To some extent, the effects on groundwater are less than on surface water because suspended solids are removed by filtration and many cationic species are removed by adsorption or ion exchange in the clay. Most organic pollutants are extensively removed by organic soils, but are removed only to a limited extent by clays.

Assuming that any ponds or landfills are protected by impermeable bottom liners when necessary and by protective covers, contamination of groundwater should be minimized. The deposition of airborne particulates on soils will be of insufficient quantity to affect groundwater.

4.4.3 Mitigating Measures

The mitigating measures have been discussed in detail in Sections 2.4.2, 2.4.3, and 4.4.1 in considering the various wastes released. These mitigating measures include collection and treatment of coal-pile runoff. Coarse ash (bottom and cyclone) is used on highways or is compacted and disposed of in a sanitary landfill where percolation through the ash will be minimized. Fine fly ash is disposed of where impermeable layers can be placed above and below the ash. Scrubber sludges are dried to the maximum degree possible. Various substances can be added to solidify the sludge and decrease the water permeability. Finally, if necessary, the sludge can be disposed of between impermeable clay or synthetic-membrane layers.

4.5 SOILS

4.5.1 Impacts

The principal impact to soils resulting from the proposed action would occur during the construction of the coal-storage facility. The Sawmill Series soils found at the proposed coal-storage site, about 1.3 ha (3.2 acres), are substantially disturbed. These soils would be disrupted during the grading and compaction necessary for preparing a raised base for the coal-storage pile and the construction of a dike to protect the stored coal during flooding of Sawmill Creek (see Sec. 2.4.2.3). Compaction of the Sawmill soils used in the construction of the raised base of the storage pile will make the base relatively impermeable and limit the movement of leachate from the stored coal into the surrounding soils and groundwater (see Sec. 2.4.2.3); however, the compacted soil material underlying the storage pile will become contaminated during the active life of the storage area. The effect on the chemical and physical properties of the Sawmill soils due to long-term infiltration of coal fines, dissolved minerals, and trace elements contained in the leachate from the stored coal is unknown. However, it is likely that the capacity of these soils to support plant growth will be greatly diminished.

Some increase in particulate emissions will occur as the result of the coal conversion of Boiler No. 5, and the operation of the fluidized-bed combustor in Boiler No. 1, despite the use of particulate-control devices. Therefore, local soils will be subject to increased deposition of airborne particulate matter, including adsorbed trace elements. The long-term effect of this increased exposure is unknown.

4.5.2 Mitigating Measures

The area where the coal is to be stored has already been disturbed, and much of it is covered with layers of coal. Mitigation of soil damage is to be accomplished by situating the coal pile in the disturbed area and by limitation of the pile area.

4.6 ECOLOGY

4.6.1 Terrestrial Impacts

4.6.1.1 Vegetation

The destruction of a small area of the old-field plant community presently occupying the proposed 1.3-ha (3.2-acre) site for coal storage will be the principal construction impact on vegetation. Following the initial stockpiling of coal, windblown dust from the storage pile could also adversely affect surrounding vegetation. Deposition of dust on vegetation may result in the plugging of leaf stomates, leaf necrosis, and lowered photosynthetic activity (Dvorak et al. 1978). However, applications of surfactants to, and compaction of, the stored coal should adequately control dust dispersion due to wind action.

The combustion of coal in Boiler No. 5, and the conversion of Boiler No. 1 to a coal-fired fluidized-bed combustor, will result in increased gaseous pollutants being released to the atmosphere. The component of these emissions most likely to adversely affect the vegetation in the vicinity of the boiler plant is SO_2. The relative sensitivities of some locally occurring plant species to SO_2 are presented in Table 4.10. Symptoms indicating SO_2 injury to plants have been arbitrarily divided into three categories: acute, chronic, and physiological and/or biochemical injuries (Varshney and Garg 1979). Acute injury is caused by the rapid absorption of SO_2 during short-term exposures (< 1 hour to 1 month) at toxic SO_2 concentrations exceeding 2860 $\mu g/m^3$, whereas chronic injury results from a prolonged exposure (usually lasting from several days to months or even years) to sublethal SO_2 concentrations of less than 2860 $\mu g/m^3$ (Dvorak et al. 1978, Varshney and Garg 1979). Physiological injury is characterized by the modification of physiological processes (e.g. photosynthesis) resulting from SO_2 exposure. Biochemical SO_2 injury results from the inactivation of enzymes or the alteration of other biochemical processes (Varshney and Garg 1979).

In most species, leaf areas collapse during intense exposure to SO_2. Initially, the affected areas appear dull or water-soaked, later drying to a

Table 4.10. Plant Species of the ANL Site for Which a Relative Sensitivity to SO_2 Is Known[a]

Common Name	Scientific Name	SO_2 Sensitivity Grouping[b]
Grasses		
Bluegrasses	Poa spp.	Sensitive/intermediate
Forbs		
Aster	Aster sp.	Sensitive/intermediate
Bindweed	Convolvulus sp.	Sensitive/intermediate
Common dandelion	Taraxacum officinale	Sensitive
Common milkweed	Ascelepias syriaca	Sensitive
Common thistle	Cirsium sp.	Intermediate
Goldenrod	Solidago sp.	Sensitive
Ragweeds	Ambrosia spp.	Sensitive
Sweet clover	Melilotus sp.	Sensitive
Violets	Viola spp.	Sensitive
Trees and shrubs		
Ashes	Fraxinus spp.	Sensitive
Blackberry	Rubus sp.	Sensitive
Cherries	Prunus spp.	Sensitive/intermediate
Hawthorns	Crataegus spp.	Intermediate/resistant
Jack pine	Pinus banksiana	Sensitive
Red oak	Quercus rubra	Resistant
Red pine	Pinus resinosa	Sensitive
White oak	Quercus alba	Intermediate
White pine	Pinus strobus	Sensitive

[a]Adapted from Dvorak et al. (1978).

[b]The SO_2 sensitivity grouping is often influenced by the specific criteria used in the ranking process. Most of the listed species were ranked by the percentage of foliar injury induced by a given dose of SO_2.

whitish-yellow or ivory color--but affected leaf areas appear brown to brownish red in some species (Dvorak et al. 1978, Varshney and Garg 1979). Symptoms of chronic SO_2 injury may also include the bleaching of chlorophyll from interveinal leaf areas until they become nearly white. Affected areas may later change to a brownish-red color (Dvorak et al. 1978, Varshney and Garg 1979). Leaf tissues may not collapse at this stage, but the leaf itself may be abscised (Varshney and Garg 1979).

The SO_2 emissions (see Sec. 3.3.5) predicted to occur during any of the proposed operating scenarios (i.e. burning coal without emission controls, with emission controls, and with both Boiler No. 5 and the coal-fired fluidized-bed combustor in Boiler No. 1 operational) do not approach or exceed the SO_2 concentrations known to cause acute or chronic injury to most plant species. However, plant species and varieties exhibit considerable variation in sensitivity to SO_2 (Dvorak et al. 1978). This variation is the result of complex interactions between microclimatic (e.g. temperature, light, humidity) and edaphic factors, as well as the phenological, morphological, and genetic characteristics of individual plant species. In other words, concentrations of SO_2 that may kill one species may not affect another species (Dvorak et al. 1978). It is impossible to predict the responses of the locally occurring plant species to the increased SO_2 emissions resulting from the proposed actions, but it appears that even the most SO_2-sensitive species would not be significantly affected under normal operating and meteorological conditions. However, during periods of plume downwash, ground-level SO_2 concentrations may be sufficient to cause transient changes in the physiological and/or biochemical processes of exposed plants. Nevertheless, the duration and frequency of downwash episodes will probably not be sufficient to cause permanent damage to vegetation. Downwash effects will occur only within a few hundred meters of the boiler house.

Particulates entrained in stack emissions during the combustion of coal in Boiler No. 5, and in the fluidized-bed combustor in Boiler No. 1, also may affect the surrounding vegetation. Airborne particulates, including adsorbed and potentially toxic trace elements, will be variously deposited on local soils; the trace elements may subsequently be available for uptake by vegetation. The annual rate of particulate deposition that will occur in the immediate vicinity of the boiler plant is unknown, but any addition of trace elements to local soils will likely be small. Unfortunately, the long-term impact of particulate-borne trace elements on vegetation has not been adequately quantified (Dvorak et al. 1978).

The proposed actions will result in large quantities of fly ash and bottom ash that could, as an alternative, be deposited in the ANL sanitary landfill (see Secs. 2.2.2 and 2.4.3). The ash would probably be compacted in layers over deposited waste material; filled areas would subsequently be covered with a layer of topsoil or other soil material, and revegetated. Roots of plants used to revegetate the filled landfill area may or may not penetrate into the ash, depending on the thickness of the soil mantle and the chemical characteristics of the ash. If root penetration of the ash occurs, the potential exists for trace elements contained in the ash to be concentrated to toxic levels in plant-shoot and/or -root tissue. Unfortunately, plant uptake of the trace elements contained in buried compacted coal ash is poorly understood, and existing information is insufficient to predict the potential impacts on vegetation as the result of this ash-disposal method.

4.6.1.2 Wildlife

The principal impact to wildlife due to the proposed actions would be the loss of small-animal habitat and fallow-deer forage resulting from the construction of the coal-storage facility. The more mobile of the resident animals will be displaced to the old-field communities adjacent to the proposed coal-storage site, but because these areas are probably now at their carrying capacity, the total number of individuals of a given species will be permanently reduced (Dvorak et al. 1978). The loss of forage accompanying the construction of the coal pile will probably not have an adverse effect on the fallow-deer population because of the presence of other suitable forage areas on the ANL site.

Noise generated during the unloading of coal-hopper cars, operation of coal conveyors, and operation of mobile equipment used to reclaim coal from the storage pile may affect wildlife in the immediate vicinity of the coal-storage area (Dvorak et al. 1978). The effects of noise resulting from intermittent activities are thought to be less severe than effects of continuous noise, as determined with captive laboratory animals (Memphis State 1971). Some animals will avoid the coal-storage area during periods of activity; others will adapt to the noise (Dvorak et al. 1978).

Also, wildlife may be affected by the increase in emissions resulting from operation of the coal-fired Boiler No. 5 and the fluidized-bed combustor in Boiler No. 1. Inhalation of SO_2 released to the atmosphere by coal combustion can irritate or cause injury to the respiratory passageways and other mucosal tissues of exposed animals (Dvorak et al. 1978). However, the predicted ambient ground-level concentrations associated with all operational scenarios fall well below the SO_2 concentrations associated with acute or chronic injury in laboratory animals (Dvorak et al. 1978). Although data based on animal exposures under laboratory conditions are a tenuous basis for extrapolating effects on wildlife in the vicinity of the boiler plant, it is doubtful that the concentrations of this pollutant will be sufficient to cause injury.

Particulate-matter emissions from the retrofitted boiler plant may also adversely affect local wildlife populations. The effects of inhalation or ingestion (by consuming contaminated water or food) of particulate matter and adsorbed trace elements on exposed wildlife are poorly understood. Inhaled particles can deposit in the alveolar regions of the lung, thus providing trace-element access to the bloodstream and subsequent transport to various internal organs (Dvorak et al. 1978). However, to determine whether a real threat to wildlife exists from long-term inhalation of the low levels of particulate matter emitted by the boiler plant, specific information on the particle size of the fly ash emitted, meteorological parameters, stack height, location of animals relative to the plume, inhalation volume of affected animals, and animal dose-response is required (Dvorak et al. 1978). Investigations relative to intake of trace elements by wildlife through ingestion of dust-coated vegetation or contaminated water have not been identified.

4.6.2 Aquatic Impacts

Aquatic biota may be affected by impacts from physical, chemical, or biological sources. Physical sources of impact are those activities or structures that affect, displace, or destroy aquatic habitat, e.g. construction of a dam or channelization of a stream. Biological sources of impact are the introduction of nonindigenous species that may prey on, parasitize, or compete with indigenous species. Chemical-impact sources are those that affect the composition and/or quality of aquatic habitat or water, e.g. an effluent containing toxic materials or solids.

The proposed conversions of Boilers No. 5 and No. 1 and the various alternatives may produce chemical alteration of the water in which aquatic biota live. Because construction or other activities will not occur in or contiguous to existing aquatic resources, and no other species of aquatic organism will be introduced to the area, the major potential sources of impact to aquatic biota are chemical discharges. No coal- or combustion-waste products will be directly released into any aquatic resource. Existing releases of boiler blowdown and cooling water are controlled by NPDES regulations. These discharges should not change in chemical composition or amount after conversion (see Sec. 4.4.1.1). Therefore, potential chemical impacts to aquatic biota may result from uncontrolled releases of materials, which are dissolved in or carried by runoff or leached into groundwater, that eventually reach local streams or ponds.

4.6.2.1 No Action

Potential impacts to aquatic biota in Sawmill Creek may occur from coal-pile runoff and/or leaching of runoff residue in areas where runoff has dried. The existing 2700-t (3000-ton) stockpile is old coal (in location since 1973), which can yield greater amounts of some contaminants than fresh coal, e.g. total suspended solids and sulfate (see Table 4.7). Undoubtedly some runoff containing contaminants leached from the coal pile reaches Sawmill Creek, but any effect would be undetectable. The existing poor water quality in Sawmill Creek (see Tables 3.11 and 3.12) is such that small contributions of materials from coal-pile runoff would be negligible. Biota in the stream are currently exposed to the elevated chemical content of the stream and would not be stressed additionally to any detectable degree by intermittent inputs of runoff, which would be diluted by elevated stream-discharge levels, during storm events. The potential for leachate to reach the stream is low due to the low permeability of the soils in the area (see Table 3.2).

4.6.2.2 Burning High-Sulfur Coal

Conversion of Boilers No. 5 and No. 1 to burn high-sulfur coal will produce several new sources of chemical impact to aquatic biota. The size of the present emergency coal stockpile will increase to about 18,000 t (20,000 tons) and be used as active storage. The pile will be placed in an area of 0.56 ha (1.38 acres) with a base of compacted earth to decrease leachate access to groundwater. Collection within berms, and treatment in the lime pond, should reduce the potential for impacts to aquatic biota from runoff to an insignificant level.

Potential impacts to aquatic biota from coal handling may occur if coal dust reaches the stream; however, dust control with foam-dust depression (see Sec. 2.4.2.2) should preclude any significant amounts of coal dust from reaching Sawmill Creek or other aquatic resources in the area.

Runoff may occur from ash deposited on streets (by the Du Page County Highway Department during icy weather) or from the disposal points of street-cleaning debris. Alternatively, ash may be disposed of in the sanitary landfill onsite. The bottom ash is resistant to leaching due to its ceramic nature, but the large-particle fly ash may contribute some contaminants to runoff or in leachate. Leach tests and state and federal rulings will determine whether treatment or a lined and capped disposal site is necessary. Proper disposal should prevent any detectable effect on aquatic organisms.

Small-particulate fly ash from the baghouse has the greatest potential for affecting aquatic biota because it contains high levels of toxic elements that may be easily leached or dissolved and carried by runoff (see Sec. 4.4.1.2). Small-particulate fly ash produced with a wet-scrubber system could be disposed of at the sanitary landfill, with insignificant effect on aquatic biota, if leach tests indicate that no harmful materials are present. Otherwise, a lined and capped disposal site would be necessary to protect aquatic resources.

Disposal methods for wet-scrubber sludge, as described in Section 2.4.3.2, all indicate that a lined disposal site is necessary or that the sludge be dewatered and fixed to reduce runoff and leaching problems. Impermeable liners and covers for disposal sites should reduce potential impacts to aquatic organisms to an acceptable level. Dry-scrubber sludge and fly ash may be similarly disposed of using an impermeable cover, if it is found necessary. Inasmuch as dry-scrubber sludge does not contain water that must be disposed of, it is the preferred system.

An alternative to onsite disposal of combustion products is offsite disposal at an approved landfill. Depending on tests and future EPA decisions, a landfill lined with an impermeable soil or clay and covered with a similar material to prevent intrusion of water could be required.

4.6.3 Mitigating Measures

4.6.3.1 Terrestrial

The impacts to vegetation and wildlife in the vicinity of the proposed coal-storage facility are minimized by constructing the facility in a previously disturbed area, thus avoiding destruction of the old-field plant community and the loss of small-animal habitat and fallow-deer forage that presently exists at the proposed site. The Sawmill Creek floodplain will not be affected other than inadvertently during construction or by airborne pollutants.

4.6.3.2 Aquatic

Because the major sources of impact to aquatic organisms result from chemical contamination of aquatic resources, the mitigative measures most useful are those that reduce the potential of contaminated runoff or leachate for reaching aquatic systems. These are lining and covering all disposal sites with impermeable materials such as clay and collecting and treating runoff prior to discharge.

The ANL sanitary landfill has been proposed as an alternative disposal site for combustion-waste products. Although the site is serviceable with installation of the necessary coverings, an offsite EPA-approved waste-disposal area can also be used.

4.7 SOCIOECONOMICS, ESTHETICS, AND LAND USE

4.7.1 Socioeconomic Impacts

Neither the proposed actions nor any of their alternatives would have a measurable impact on the area's population and settlement pattern. Similarly, the local housing market would not be affected because the workers involved in the conversion would be few and already live within commuting distance of the site. The employment impact would also be small for the area. At most, 50 workers would be required during the construction period; about two, permanent, operating employees would be added.

The proposed project would use existing roads and rail lines. Workers would commute to the site; trucks and construction vehicles would use the roads to and within the site. Coal might be transported by truck (3 to 4 loads per day), or by rail at the rate of 400 to 800 cars yearly using 50- to 100-ton cars. Because of ANL's proximity to existing highways and rail lines, the traffic generated is not expected to impede local transportation. Traffic onsite is not expected to suffer unless coal is moved by truck, about one thousand 40-ton trucks yearly. Slow-moving trucks might constrict traffic flow during deliveries.

The noise generated by the proposed actions would be muted by the distance of the work from most ANL facilities; and it is more than a kilometer from residences in the area, with intervening wooded areas.

4.7.2 Esthetic Impacts

The visual impacts of the proposed actions will vary according to the scheduling of air-pollution-control installation. The existing view generally includes a number of artificial structures, both within the ANL site and in the area, but the area is also well forested. From off the site, trees block most of the view of the existing boiler except for the three stacks, which can be seen from high points for several miles. Stack height will not change.

Once all air-quality-control equipment is installed, it is probable that the visible steam plume will not be perceived as a significantly adverse change in the view. On some days the plume will quickly evaporate in the atmosphere. The plume will be more dense with condensation on overcast and humid days when it will not stand out in great contrast to the sky, or on cold and often clear days when it will be more visible. If a dry scrubber is used, the amount of steam in the plume would be much less than if a wet scrubber were used and, therefore, its opacity and size would be less.

During the first year, when pollution-control equipment will not yet be installed, the stack plume will be dark. Particulates and SO_2 will be present, (see Sec. 4.1.1).

4.7.3 Land-Use Impacts

The proposed actions, or their alternatives, are not expected to constitute a change in land use at the boiler site. Coal-ash wastes would be used by the Du Page County Highway Department on icy roads, disposed of on the ANL site in the existing landfill, or trucked offsite to an EPA-approved landfill.

The volume of scrubber sludge would vary according to factors explained in Section 2.4.3.2. Landfill design would also affect the total area required for waste disposal. However, it may be roughly calculated that only about 4000 to 8000 m^3 (3.2 to 6.4 acre-ft) of dry-scrubber sludge may be generated annually (Duvel et al. 1979). Scrubber sludge would be disposed of at a state-approved facility offsite. Waste disposal is not expected to create any change in land-use classification.

4.7.4 Mitigating Measures

The use of rail cars to deliver coal for use at Boilers No. 1 and No. 5 would eliminate competition for road space within the ANL site. Any traffic congestion onsite due to coal cars at rail crossings may be reduced by scheduling those vehicles to avoid commuter rush hours.

A dry-scrubber system would produce more-manageable sludge wastes, probably with less total volume, than would a wet-scrubber system. Therefore, less landfill capacity would be consumed annually. A dry scrubber would also reduce the opacity of the stack plume, mitigating its visual impact.

4.8 UNAVOIDABLE ADVERSE ENVIRONMENTAL IMPACTS

4.8.1 Physical

4.8.1.1 Land

About 1.3 ha (3.2 acres) of land will be required for the coal-storage area. Part of this land has been used for coal storage previously (about 0.5 ha or 1.2 acres) and the remainder is old field. Assuming a depth of 3 m (10 ft), about 0.1 ha (0.25 acre) per year will be required for ash disposal and 0.2 ha (0.5 acre) per year for scrubber sludge.

The coal-storage area will probably be available for other use after the coal is eventually removed. The sludge- and ash-disposal areas, after stabilization, may have long-term restrictions on their use.

4.8.1.2 Water

An increased consumption of water (3.4 m^3/h or 900 gal/h) will be required by the dry-scrubber system. This will be about 2% of the daily ANL use. No other changes in water use will occur. Runoff from the coal, ash, and sludge piles will be controlled so that the effects on surface water and groundwater will be within EPA and state requirements and generally undetectable.

4.8.1.3 Air

The burning of coal rather than natural gas will cause increased emissions of SO_2, particulates, and trace contaminants. However, these emissions will be controlled to within limits set by the state and the USEPA. In the interim period before the emission-control devices are installed, emissions will be high but within state and federal limits. The area will remain nonattainment for secondary and attainment for primary particulate ambient air-quality standards. The added particulate loading from the boiler during the interim period should contribute only an additional 10% of the current TSP levels. There will be no violations of any ambient SO_2 standards.

4.8.2 Biological

Vegetation now occupying the coal-storage area will be destroyed. As a consequence, associated small-animal habitat and fallow-deer forage will be lost. The areas of habitat destroyed constitute only a very small part of similar areas on the ANL site; therefore, there will be little damage to the ANL biota as a whole.

4.8.3 Socioeconomic

Traffic congestion may result if coal and limestone are transported by truck onto the site. However, rail transport would eliminate competition for road space. Also, delivery scheduled to avoid rush hours would alleviate the situation.

During the initial months when emission-control devices for Boiler No. 5 are not yet in operation, the stack plume may appear more opaque and more noticeable to residents of neighboring areas. Subsequent installation of the air-pollution-control equipment would tend to remedy any visibility problem. In contrast, Building No. 1 will operate only with control equipment in place.

4.9 THE RELATIONSHIP BETWEEN SHORT-TERM USES OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

The proposed actions are, in essence, a conversion from the use of fuels in relatively short supply (natural gas and oil) to the use of one in much greater abundance (coal). The use of fuel is necessary for the operation of ANL and is unavoidable. A large part of the work at ANL is research on new energy sources or on conservation of existing sources; consequently, the use of energy at the Laboratory might be expected to enhance the development of future energy sources.

4.10 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

The construction materials needed for converting Boiler No. 5 and replacing Boiler No. 1 will consist of relatively small quantities of steel and concrete. The steel will probably be recoverable as scrap. There are essentially unlimited reserves of the components of concrete.

In operation, the consumption of natural gas and fuel oil equivalent to about 1.4×10^{15} J (1.3×10^{12} Btu) annually will be replaced by the consumption of coal. This consumption is irretrievable and irreversible. About 9300 t (10,300 tons) of limestone will be consumed annually. Resources of this material are essentially unlimited.

The small areas of land used for ash and sludge deposition may have long-term restrictions on their use.

4.11 POSSIBLE CONFLICTS BETWEEN THE PROPOSED ACTIONS AND THE OBJECTIVES OF FEDERAL, REGIONAL, STATE, AND LOCAL LAND-USE PLANS, POLICIES, AND CONTROLS

The proposed action of converting Boiler No. 5 to coal is required under a "Proposed Prohibition Order," issued on 12 September 1979 by the Economic Regulatory Administration under the "Fuel Use Act." All construction will be above the 100-year floodplain of Sawmill Creek; thus, a floodplain assessment is not required under Executive Order 11988, "Flood Plain Management."

Plans for the conversion or replacement and subsequent operation with coal in Boilers No. 1 and No. 5 are designed to meet applicable federal and state air and water-quality standards, as well as to comply with the current NPDES permit issued to DOE for the Laboratory by the USEPA. Furthermore, standards established by the Occupational Safety and Health Administration and by ANL health-and-safety regulations were taken into consideration in planning the conversion and subsequent operation of the boilers.

All construction and storage areas will be on federally owned property and subject to applicable federal regulations. Ash and sludge may be disposed of on publicly or privately owned landfills outside the ANL site. These sites will be required to meet local, state, and federal standards.

4.12 ENERGY AND DEPLETABLE-RESOURCE REQUIREMENTS AND CONSERVATION POTENTIAL OF VARIOUS ALTERNATIVES AND MITIGATING MEASURES

The primary purpose of the proposed actions is to substitute coal for natural gas and fuel oil. The consumption of about 3.5×10^7 m^3 (1.22×10^9 ft^3) of natural gas and 2900 m^3 (760,000 gal) of fuel oil will be replaced by the consumption of 50,000 t (55,000 tons) of high-sulfur coal each year. Conservation is attained in that coal is relatively abundant, and oil and gas relatively scarce, within the United States. However, the burning of coal will require about 3% of the total energy input to operate the SO_2-scrubber system (York Res Corp 1980).

Alternative SO_2-scrubbing or coal-burning systems show only slight differences in energy efficiency, although substantially more efficient systems may be available in the future. The potential for energy conservation using other alternatives is discussed in Section 2.3.

The construction materials and limestone used during operation are relatively abundant and their use will have no perceptible effect on available quantities.

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